THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. VIII.—*Astronomical Observations on the Atmosphere of the Rocky Mountains, made at elevations of from* 4,500 *to* 11,000 *feet, in Utah and Wyoming Territories and Colorado;* by HENRY DRAPER, M.D., Professor of Analytical Chemistry and Physiology in the University of New York.

ANYONE who observes with a large telescope soon becomes aware of the great obstacle atmospheric undulation offers to the pursuit of astronomy, particularly in the application of photography and the spectroscope. During two years when I photographed the Moon on every moonlight night at my observatory* there were only three occasions on which the air was still enough to give good results, and even then there was unsteadiness. Out of 1,500 lunar negatives only one or two were really fine pictures. A letter which the late Mr. Bond wrote to me states that in seventeen years he had never met with a perfectly faultless night at the Cambridge Observatory.

Such facts naturally cause astronomers to consider whether it is not possible to diminish atmospheric disturbances, and have led to the celebrated expeditions of Professor Piazzi Smyth to the Peak of Teneriffe and Mr. Lassell to Malta. Theoretically, it would seem that the only complete solution is to ascend high mountain ranges or isolated peaks, and leave as much as possible of the air below the telescope.

Having had occasion during the months of August and September, 1876, to go on a hunting trip with two distinguished officers of the United States Army into the Rocky Mountains

* Professor Henry Draper's Observatory is at Hastings-on-Hudson, near New York; latitude 40° 59′ 25″; longitude 73° 52′ 25″; elevation above the sea, 225 feet.

and Wahsatch range, I thought it desirable to carry a telescope with a view of ascertaining whether there would be sufficient inducement to return with my twelve-inch achromatic or twenty-eight-inch reflector and make a prolonged stay. The experience which Professor Young had had at Sherman station, on the Union Pacific Railroad, left the question open, for he suffered from an unusually cloudy season, and, while he obtained very gratifying results, he seems on the whole to have been disappointed with the character of the atmosphere.

As the region into which the party proposed to go was difficult of access and entirely without roads and much of the traveling was to be on horseback, through fallen timber and up precipitous places, it was not feasible to take an instrument of any great size. I therefore contented myself with a small achromatic of unusual excellence. Though of only one and one-quarter inches aperture, it bears a power of upwards of sixty completely, and I think would carry one hundred. It was provided with a short brass tripod, holding an altitude and azimuth movement, giving both steadiness and smoothness of action. The eye-piece was capable of adjustment by a rack and pinion, and the object-glass was so arranged in its cell as to be free from injurious compression. This little lens stands the severe tests invented by Foucault, and in spite of its size is capable of doing good work.

In such observations on the atmosphere as those proposed during this trip, it is obvious that there are mainly two points to be considered: first, freedom from tremor, and second, transparency. A station which combines both is most desirable, but a marked predominance of steadiness gives special advantages for celestial photography while increase of transparency even if accompained by unsteadiness is of value in eye observations. I had been led to suppose, from conversations with Government officers and persons connected with the geological and geographical surveys of the Territories, that the Wahsatch range, which is intermediate between the Sierra Nevada on the west and the true Rocky Mountains on the east, would offer the greatest advantages. This supposition turned out to be altogether incorrect, though it might have been argued that a high range flanked at a distance on either side by other higher ranges should have given the maximum chance for cloudless and still skies.

We first went to Salt Lake City, which, according to the Casella aneroid I carried, is at an elevation of 4,650 feet above the sea. It lies at the foot of the Wahsatch range. At eleven o'clock on the evening of arrival, August 25th, I took some observations from the hotel, after carefully centering the object-glass. Saturn looked about the same as on an ordinary

night at my observatory. Capella, which was just clear of the house-tops across the street, twinkled as badly both to the naked eye and in the telescope as I have ever seen it at the sea-level. Lieutenant Warren, of Camp Douglas (a military post near the city) said there had been a heavy rain the week previous and the air was more moist than usual. I had noticed that the sun set among just such a bank of clouds as we are accustomed to see in New York. I was somewhat prepared for a tremulous condition in these high regions, because, the preceding night having stopped for a few minutes at Fort Steele, on the Union Pacific Railroad, I perceived that Antares twinkled very much though we were nearly 7,000 feet above the sea.

However, in order to make a thorough trial it seemed best to ascend one of the high peaks of the Wahsatch, and accordingly the Red Butte was selected. The officers at Camp Douglas facilitated the trip in every way, furnishing horses and a guide, and the surgeon of the Post, Dr. Smart, who is an able and scientific man, accompanied me. The peak proved to be 7,350 feet high. Though it was quite clear when we started, clouds gathered in every direction as the sun went down, and at nightfall the sky was entirely overcast. Moreover, the wind blew so strongly that it was necessary to retire over the brow of the mountain, and eventually we returned to Camp Douglas. At this point, 5,250 feet above the sea and about 600 feet higher than Salt Lake City, the telescope was set up to take advantage of some breaks in the clouds, through which the Moon, Antares, ζ Ursæ Majoris and Jupiter appeared. With a power of only twenty the twinkling was surprisingly great; I do not remember ever to have seen it worse with my large instruments.

These results led to an examination into the meteorology of Salt Lake City, so as to find out the rainfall and its distribution and the percentage of cloudy days. Dr. Smart had the following copy of the post records made for me:

TABLE I.—*Rainfall and other Cloudy Days at Salt Lake City.*

	JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
	Rain fall & melted Snow.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.
1872	1·30	--	2·60	19	1·20	--	2·04	--	2·34	16	·58	11
1873	2·18	23	1·89	19	·90	11	2·00	10	4·10	16	·24	5
1874	1·28	18	1·03	17	2·87	21	·77	16	2·89	16	·72	13
1875	2·21	31	·80	28	2·37	31	1·05	23	3·29	4	1·10	7
1876	1·22	27	·90	23	4·00	28	1·79	17	4·04	19	·14	7

TABLE I—continued.

	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.	Rain fall.	Cl'dy days.
1872	·02	10	·72	16	·94	9	1·44	13	·66	16	2·26	15
1873	·12	7	·94	14	·42	6	·84	13	·38	10	1·20	24
1874	2·12	10	2·11	9	·30	6	1·89	27	2·26	26	1·06	27
1875	·64	14	0	6	1·15	13	1·48	18	4·54	30	2·78	31
1876	1·08	6										

From Table I, it appears that the average annual rainfall for the past five years is $18\frac{4}{5}\frac{0}{5}$ inches, distributed as shown in Table II. There is no perfectly dry month, the nearest approach being during the summer. The cloudy days are 194 per annum, the disposition being similar to the rainfall.

TABLE II.

January,	1·64	inches of rain.	25	cloudy days.
February,	1·44	"	21	"
March,	2·27	"	23	"
April,	1·53	"	16	"
May,	3·33	"	14	"
June,	·56	"	9	"
July,	·80	"	9	"
August,	·94	"	11	"
September,	·70	"	8	"
October,	1·41	"	18	"
November,	1·96	"	20	"
December,	1·82	"	24	"

A former pupil of mine, and graduate of the University, Dr. Benedict, informed me that the Mormons believed the rainfall had much increased since their community had settled in Utah, and this seems to be borne out by the statement that whereas formerly three gallons of Salt Lake water produced on evaporation one gallon of salt it now takes four gallons to produce the same quantity.

On the whole it is doubtful whether there would be enough advantage in bringing a large telescope to this region to make it worth while to encounter the labor and expense.

On August 30th, having taken an escort we moved south from Fort Steele, latitude 41° 48′, longitude 107° 09′, along the north fork of the Platte River into the main range of the Rocky Mountains. During the fifteen days' expedition there were only two nights on which we saw clouds enough to prevent astronomical working, and only one thunder storm of any moment took place in our immediate vicinity; about one-quarter of an inch of rain fell. The sky was rarely perfectly

free from clouds and many local thunder storms occurred about the higher peaks, but they seldom extended to the plateaus below.

September 1st and 2d our camp was 8900 feet above the sea in the vicinity of mountains rising 10,000 and 11,000 feet. These peaks seemed to be nearer than they really were, for the transparency of the air causes estimates of distance to be deceptive. From the top of one I subsequently saw the Seminole mountain which was 150 miles distant; it did not appear to be 50 miles away. The night of Sept. 1st was quite clear, with very little cloud, and the atmosphere remarkably tranquil. Antares, when near setting, hardly twinkled at all, and Arcturus in the telescope exhibited four diffraction rings unbroken by flickering. The central disc was as hard and sharply defined as the pinhole in the lamp screen I am accustomed to use in testing specula and lenses. I looked for the companion of Polaris, but partly on account of the nearly full Moon, and partly from the thickness of the diffraction rings, I could not be sure of it. The Moon was perfectly steady; with a power of 60 there was no trace of twinkling at the terminator. I tried to see Titan, the largest satellite of Saturn, but did not succeed. At the time it was not certain whether this failure was due to the position of Titan with relation to Saturn, or whether it arose from the blinding effulgence of the Moon. Capella was perfectly steady though there was a slow change of color from bluish to reddish occupying about a second.

The succeeding night at nine o'clock, though the sky was mostly covered with cumulus clouds in motion southward, I was surprised to find the terminator of the Moon absolutely free from twinkling, and Arcturus down among the tops of the dead aspen trees as steady as possible. The four diffraction rings round the central disc were not perfectly circular, but that was the fault of the lens. Every defect of centering or of surface, and any vein in the glass comes out even more clearly than in the workshop examinations, because while the air is as steady the light is far more intense.

I am certain if a large telescope could be brought here and maintained against the furious winds great results might be attained if there is much of this weather. But this particular place is difficult of access and possibly no better than other situations on the line of the railroad. The sky is not as black as I had expected; it is rather of a light blue, though the full Moon makes much difference.

On several other nights in both lower and higher places I made observations but never saw the combination of steadiness and transparency again. On the plateaus at the foot of the mountains and away from the groves of aspen trees and pines

the sun sends down scorching rays all day long on the alkali plains where only sage plants are sparsely scattered, and even on horseback one can see the heated waves rising from the ground. The air is far from being moist for the lips are apt to crack and bleed, and the mucous membrane of the nose is parched. When the sun sets the ground radiates rapidly, and we frequently had by morning one-quarter of an inch of ice in our vessels of water standing outside the tents. These plateaus are on an average about 7250 feet above the sea. The mere fact of broken ground and wooded surroundings does not however suffice to produce, even at this season, a tranquil air, for when we rode over the Rocky Mountains along the margin of perpetual snow to the headwaters of Snake River, and camped at Trout Lake nearly 10,000 feet high, though the air was exceedingly transparent it was very unsteady. I rose at four A. M. to see Venus, and her splendor was so great that it led to a most delusive estimate of her apparent size. Occasionally during clear frosty weather in midwinter a night of similar characteristics is seen at my observatory. On such an occasion I obtained at the principal focus of the 15½-inch reflector a photograph of the Moon near her third quarter in less than a second.

The officers of Fort Steele and the guides say it would be impossible to do any astronomical work in this region from the middle of October till the middle of May, that is, for seven months. The fierce winds, heavy falls of snow and intense cold would be unbearable. Even in the beginning of September we needed large camp fires in the morning and evening. Our camp at Trout Lake could only be reached for six weeks in summer on account of the depth of snow in the fallen timber.

On the whole it may be remarked of this mountain region that the astronomical condition, particularly for photographic researches, is unpromising. In only one place were steadiness and transparency combined, and only two nights out of fifteen at the best season of the year were exceptionally fine. The transparency was almost always much more marked than at the sea level, but the tremulousness was as great or even greater than near New York. It is certain that during more than half the year no work of a delicate character could be done. At the end of August in sheltered positions, and in good tents, we slept under half a dozen thicknesses of blanket and only partially undressed. Such a degree of cold distracts the mind and numbs the body. Apparently, therefore, judging from present information, it would not be judicious to move a large telescope and physical observatory into these mountains with the hope of doing continuous work under the most favorable circumstances.

ART. IX.—*Photographs of the Spectra of Venus and α Lyræ.* Note by Prof. HENRY DRAPER, M.D.*

SINCE the spring of 1872 I have been making photographs of the spectra of the stars, planets and Moon, and particularly, among the stars, of α Lyræ and α Aquilæ with my 28-inch reflector and 12-inch refractor. In the photograph of α Lyræ, bands or broad lines are visible in the violet and ultra-violet region unlike anything in the solar spectrum. The research is difficult and consumes time, because long exposures are necessary to impress the sensitive plate, and the atmosphere is rarely in the best condition. The image of a star or planet must be kept motionless for from ten to twenty minutes, and hence the driving clock of the telescope is severely taxed.

During last summer I obtained good results, and in October took photographs of the spectrum of Venus, which show a large number of lines. I am now studying these pictures, and have submitted them to the inspection of several of my scientific friends, among others Professors Barker, Langley, Morton aud Silliman. There seems to be in the case of Venus a weakening of the spectrum toward H and above that line, of the same character as that I have photographically observed to take place in the spectrum of the Sun near sunset.

New York, December, 1876.

ART. X.—*On Dinitroparadibrombenzols and their Derivatives;* by Dr. PETER TOWNSEND AUSTEN. Second Paper.

THE separation of the three isomeric dinitroparadibrombenzols I have already described in a previous paper.†

The residue from the separation of the α- and β-isomers consisted, for the most part, of β-dinitroparadibrombenzols, which forms the chief product of the nitrition. These residues were collected and, after several crystallizations from carbon disulphide, were recrystallized from glacial acetic acid. After six crystallizations, the fusing point remained constant.

Betadinitroparadibrombenzol.

The betadinitroparadibrombenzol crystallizes from its solution in carbon disulphide in thick white pointed and peculiarly bent needles. It is very easily soluble in the usual solvents,

* This article was printed on the third page of the cover of the January number, and is here reproduced without change.—EDS.

† This Journal, vol. xii, 118, 1876.

especially in glacial acetic acid, carbon disulphide, acetic ether,* alcohol, etc.

It fuses at 99°–100°† to a yellowish liquid. 0·2940 grms of substance gave 0·0330 grms. of H^2O, and 0·2418 grms. of CO^2.

Calculated for $C^6H^2(NO^2)^2Br^2$.	Found.‡
C=22·08	22·43
H= 0·61	1·24

The compound is somewhat volatile. Inspiration of its vapors occasions an intense inflammation of the mucous membranes. An alcoholic solution, when brought upon the skin, excites itching, smarting, and inflammation accompanied by subsequent peeling off of the skin. A minute quantity brought in contact with the eye causes a sharp pain lasting several days. On the more sensitive skin of the face it gives rise to a smart which, after it has attained a maximum, suddenly vanishes. It is hence a powerful excitant.

* It is very striking that nearly all substances which are soluble in glacial acetic acid, are also soluble in acetic ether.

† In a preliminary notice I gave the fusing point as 120°. The substance was not quite free from the isomeric compounds. The separation of the last traces of the isomers is exceedingly difficult. The greatest care is also necessary in the determinations of the fusing points, for the substance which fused at 120° retained the same fusing point even after four crystallizations from glacial acetic acid. A single crystallization from alcohol, however, sufficed to prove it a mixture. In a similar manner a mixture of substances, with which I have recently been working, retained an exact fusing point of 195° during seven crystallizations from glacial acetic acid, while two crystallizations from alcohol proved that two-thirds of the mixture consisted of a substance fusing at 136°.

‡ I have rarely analyzed a substance which was so refractory during combustion as this betadinitroparadibrombenzol. All attempts at burning it with copper oxide or lead chromate failed owing to the sublimation of the substance to the upper part of the tube, from which the highest attainable heat of the combustion furnace was inadequate to dislodge it. In making the combustions of this compound, as well as of many other substances encountered in this investigation, I have used a variation of the ordinary method of combustion, which has of late found an extended application in the analysis of refractory organic substances. It was suggested to me by Mr. Bauermeister of the Berlin University laboratory. I have employed it, in most cases, in preference to combustion in a stream of oxygen gas. Copper oxide, in the form of spiculæ (length about 10mm., diameter about 1 to 2mm.) having been first introduced into the tube, the substance is well mixed in a mortar with lead chromate to which its equal volume of the copper oxide is afterwards added, and the whole again well mixed. After introducing the mixture into the tube, the mortar is well washed out with a mixture of oxide and chromate (equal parts) and the washings added to the contents of the tube. The tube is then filled up with chromate, leaving room for a copper spiral, in case the substance to be analyzed contains nitrogen, and rapped on the pointed end so that the contents may compact. This having been accomplished, the tube is rapped longitudinally. The heavy pulverulent lead chromate sinks to the bottom leaving the channel filled with a net-work of copper spiculæ. The gases have to pass through this net-work and are hence exposed to a very great oxidizing surface. Loss by sublimation is entirely avoided, since the substance must necessarily be deposited on the spiculæ and by them be completely oxidized. In case the compound contains haloid elements, about two inches of the lead chromate nearest the cork end of the tube must be kept just off the red heat ("black") so as to prevent any of the haloid copper compounds, which may be formed, from passing into the potash bulbs.

Betadinitroparabromaniline.

By heating the betadinitroparadibrombenzol with alcoholic ammonia for eight hours in a closed tube at 100°, I obtained a deep red solution, from which a large mass of red scales separated on cooling. The solution was poured into cold water, and the resulting yellow precipitate dissolved in boiling absolute alcohol which contained animal charcoal, filtered, and allowed to stand. The pure substance obtained in this manner formed orange-red scales fusing at 160°.*

0·3010 grms. of substance gave 0·0506 grms. of H^2O and 0·3044 grms. of CO^2.

0·24 grms., after the method of Carius, gave 0·148 grms. of AgBr and 0·0027 grms. of Ag.

Calculated for $C^6H^2(NO^2)^2NH^2Br$.	Found.	
	I.	II.
C = 27·48	27·58	-----
H = 1·52	1·86	-----
Br = 30·53	----	30·90

The substance is easily soluble in boiling alcohol and glacial acetic acid. It is almost insoluble in water, and entirely so in carbon disulphide.

It is not acted upon by boiling amyl nitrite, although in a closed tube at 100° the substances react. No defined product was obtained, which, however, was more probably owing to the small amount of substance used than to the absence of a dinitrobrombenzol.

Strong alcoholic ammonia remained at 200° without action upon it. This, however, was not surprising, since, according to Meyer and Wurster,† only one bromine atom of the mononitroparadibrombenzol can be substituted by direct action of ammonia. A somewhat similar case is recorded by Armstrong.‡ He found that the chlorine atom of dinitrochlorphenol was not affected by ammonia. The weakening action of the nitro-groups may, perhaps, here be overcome by the formation of the ammonium salt.

When boiled with alcoholic potash the substance evolves ammonia, but the nitro-groups appear to be affected, and a general decomposition is the result.

Betadinitroparabromanilidobenzol.

On treating the betadinitroparadibrombenzol with aniline, the mass assumed a fine red color. On heating a violent reaction ensued, and the mixture boiled of itself. The solution was allowed to cool, and then treated with dilute chlorhydric acid. An oil separated and gradually solidified. The dark

* It is worthy of notice that the fusing point of this compound (160°) is nearly the same as that of the alphadinitroparadibrombenzol (159°).

† Ber. d. d. chem. Ges., v, 632. ‡ Chem. Soc. J., (2), x, 12.

violet mass was several times well washed with water, and then dissolved in boiling absolute alcohol containing animal charcoal, filtered, and allowed to crystallize. The substance forms superb orange-red fine hairy needles fusing at 120°. They are soluble in boiling glacial acetic acid and in alcohol.

0·2885 grms. of substance gave 0·0684 grms. of H^2O and 0·4444 grms. of CO^2.

0·1685 grms. after the method of Carius gave 0·0910 grms. of AgBr and 0·0016 grms. of Ag.

Calculated from the formula—

$$C^6H^2\begin{cases}NO^2\\NO^2\\NH.C^6H^5\\Br\end{cases}$$

Theory.	Found. I.	II.
C = 42·60	42·64	----
H = 2·36	2·67	----
Br = 23·66	----	23·56

Betadinitroparabromdinitroanilidobenzol.

The preceding compound was added in small portions to fuming nitric acid at a temperature of +12°. It dissolved quickly with a weak action, the color of the solution becoming darker. The resulting solution was poured into cold water, and the bright yellow powder which separated was crystallized from boiling glacial acetic acid. The substance forms small brownish yellow scales, which fuse at 167·5°.

0·2057 grms. of substance after the method of Carius gave 0·0552 grms. of AgBr and 0·0035 grms. of Ag.

The formula—

$$C^6H^2\begin{cases}NO^2\\NO^2\\NH.C^6H^3(NO^2)^2\\Br\end{cases}$$

requires 18·69 Br; 18·81 was found.

The compound is easily soluble in boiling glacial acetic acid, but with difficulty in alcohol. If it be warmed with a solution of sodic hydrate, it forms immediately a deep blood red solution, from which, after a few minutes have elapsed, the separation of glittering red and green dichroic needles takes place. This compound I take to be a sodium betadinitroparadinitroanilidophenylate—

$$C^6H^2\begin{cases}NO^2\\NO^2\\NH.C^6H^3(NO^2)^2\\ONa\end{cases}$$

University Laboratory of Berlin, July 15, 1876.

ART. XI.—*On some Points in connection with Vegetation:* by Dr. J. H. GILBERT.

[Continued from page 32.]

Amount of nitrogen assimilated by plants.—Let us now recur to the question of the various amounts of nitrogen assimilated over a given area by plants of different natural orders, and call attention to the facts bearing upon the point which these experiments on the mixed herbage of grass land have supplied.

TABLE IV.—*Yield of Nitrogen in the Mixed Herbage of Permanent Grass land at Rothamsted.*

Plots.	Conditions of Manuring.	Average Produce per acre per annum, 20 years, 1856–1875, according to Mean per cent at 6 periods 1862, '67, '71, '72, '74, '75.			Average nitrogen per Acre per annum.		
		Gramineæ.	Leguminosæ.	Other Orders.	10 years 1856–1865	10 years 1866–1875	20 years 1856–1875
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3	Unmanured	1635	219	529	35·1	30·9	33·0
4-1	Superphosphate*	1671	149	673	35·7	31·5	33·6
8	Complex Min. Manure.†	2442	296	639	54·4	38·1	46·3
7	Complex Min. Manure.‡	2579	806	573	55·2	56·0	55·6

In Table IV. is shown the average produce (in the condition of hay) in lbs., per acre, per annum, over twenty years, of herbage of the gramineous family, of herbage of the leguminous family, and of herbage of other orders, calculated according to the mean percentage of each of these, determined in separations at six periods, namely, in 1862, 1867, 1871, 1872, 1874, and 1875, in samples of the produce of four of the plots which have received no nitrogenous manure from the commencement; and there is also given, by the side of these results, the average annual yield of nitrogen per acre over the first ten, the second ten, and the total period of twenty years, in each case.

The quantities of nitrogen yielded are calculated from the results of actual determinations of the nitrogen in the mixed produce of the respective plots; but the estimates of the quantity of the produce referable to the different Natural Orders must be taken as only giving a general indication or an approximation to the truth; for, while the amount of the total mixed produce is the average of that of the twenty years,

* Mean of four separations only, namely, 1862, 1867, 1872 and 1875.

† Including potass six years, 1856–1861; without potass, fourteen years, 1862–1875.

‡ Including potass twenty years, 1856–1875.

the amount of it referred to the different orders is calculated upon their percentage determined in six years only, four of which are among the last five, and the fluctuation according to season is in some cases very considerable, while in others there is a progression in the changes, which render an accurate estimate of the average botanical composition of the herbage over the whole period impossible. The figures do, however, undoubtedly represent the truth sufficiently nearly for our present purpose. But before referring to the yield of nitrogen, it may be remarked, in passing, how much greater is the increase of gramineous produce by the use of purely mineral manures in this mixed herbage than in the case of gramineous crops grown separately. The interesting question arises, how far the result is due to the direct action of the mineral manures in enabling the grasses to form much more stem and seed—that is, the better to manure—which, as a matter of fact, they are found to do? or how far the increased growth is to be explained by an increased accumulation of combined nitrogen available for the grasses in the upper layers of the soil, as the result of the increased growth of the Leguminosæ induced by the potass-manure, as already illustrated by the results obtained in alternating clover and barley, and in an actual course of rotation?

Referring to the yield of nitrogen, it is seen that, without manure, it has diminished during the last as compared with the first ten years; but that the average is thirty-three pounds per acre, per annum, or considerably more than with a gramineous crop grown separately.

With super-phosphate of lime alone, the yield of nitrogen over the first ten, the second ten, and the twenty years, is very nearly the same as without manure. It is slightly higher as is also the total amount of produce; but while the quantity contributed by gramineous species is rather more, that yielded by leguminous species is less, and that by species belonging to other orders more than without manure.

With super-phosphate of lime, and sulphates of potass, soda and magnesia, during the first six years, but no potass during the last fourteen years (plot 8), the amount of both gramineous and leguminous herbage is very much increased; and that of the leguminous produce was especially so during the earlier years. The result is a yield of 55·4 lbs. of nitrogen per acre, per annum, over the first ten years, of only 38·1 lbs. over the second ten years, and of 46·3 lbs. over the twenty years.

With the complex mineral manure, including potass each year throughout the period of twenty years (plot 7), leguminous species contribute about one-fifth of the whole produce, or very much more than in either of the other cases. The

result is an annual yield of 55·2 lbs. of nitrogen over the first ten years; of even slightly more, or fifty-six lbs., over the second ten years: and of 55·6 lbs. over the whole period of twenty years—that is, considerably more than twice as much as would be yielded by a gramineous crop grown separately on arable land. It may here be observed that, while in the case of the first three plots referred to, the produce of the mixed herbage diminished over the second as compared with the first ten years, that of plot 7, with the potass manure, and so much leguminous herbage, increased slightly over the second compared with the first ten years. Finally, it may be remarked on this point, how comparatively uniform is the average yield of produce by all other species other than the gramineous and the leguminous on the four very differently manured plots.

Here again, then, the results relating to the growth of species of many different natural orders growing together, like those relating to the growth of individual species grown separately, show that those of the leguminous family, and probably those of various other orders also, have the capacity of assimilating much more nitrogen over a given area than species of the order Gramineæ.

Assuming for the sake of argument that the yield of nitrogen by the Gramineæ grown separately may be explained, as already suggested, by reference to the amount of combined nitrogen acquired from the measured aqueous deposits from the atmosphere, together with that condensed within the pores of the soil, and that derived from previous accumulations within it, the question arises, can the greatly increased yield by other plants be so accounted for? or, if not, how otherwise may it be explained? We will endeavor to weigh the evidence bearing upon this point.

Is the combined nitrogen in the atmosphere the source of the assimilated nitrogen?—It so happens that the plants which do gather, or which have been supposed to gather nitrogen more readily than the Gramineæ, have obviously a different character of foliage; as, for instance, the "root crops"—turnips and the like; and the leguminous crops—beans, peas, clover, etc. An obvious explanation, therefore, which will be found in books of authority, is that these so distinguished "broad-leaved plants" have the power of taking up nitrogen in some form from the atmosphere, in a degree, or in a manner, not possessed by the narrow-leaved gramineous plants. It is true that Adolph Mayer in Germany, and Schlösing in France, have experimentally shown that plants can take up nitrogen by their leaves from ammonia supplied to them in the ambient

atmosphere. But I think I am right in saying that the conclusion of both of these experimenters is that this action takes place in a very immaterial degree in natural vegetation.

In reference to this subject, I may observe that the results of the determinations of the ammonia in the atmosphere by different experimenters, and in different localities, vary very greatly; and it may be concluded that a shower of rain will wash out much of it. According to M. Schlösing's statement of the results of his recent determinations of the ammonia in the air of Paris (Compt. Rend., lxxxi, p. 1252 et seq.), it ranges from one part in about 12,500,000, to one part in about 260,000,000 of air by weight. If, for the purpose of illustration, we assume that, on the average, the ambient atmosphere in the open country—in Europe, at any rate—will contain one part of ammonia in 60,000,000 of air, or one part of nitrogen as ammonia in about 50,000,000 of air, the atmosphere would thus contain more than 8,000 times less nitrogen as ammonia than carbon as carbonic acid. But cereal crops contain one part of nitrogen to about thirty of carbon, and leguminous crops, one of nitrogen to fifteen, or fewer, of carbon. On these assumptions, the ambient atmosphere would contain a proportion of nitrogen as ammonia, to carbon as carbonic acid, about 267 times less than that of nitrogen to carbon in cereal produce, and about 534 times (or more) less than that in leguminous produce. It is true that water would absorb very much more nitrogen as ammonia, or dissolve very much more as carbonate or bi-carbonate of ammonia, than it would of carbon as carbonic acid under equal circumstances. Hence, there would appear to be a compensating quality for the small actual and relative amount of nitrogen as ammonia in the atmosphere, in the greater solubility or absorbability of the compounds in which nitrogen exists, than of the carbonic acid in which the carbon is presented. Further, it can hardly be to merely a greater extent of leaf or above-ground surface that the result could be attributed. Thus, though a bean and a wheat crop may yield about equal amounts of dry matter per acre, the bean produce would contain from two to three times more nitrogen, and approximate measurements show that a wheat plant offers a greater external superfices in relation to a given weight of dry substance than a bean plant, and greater still therefore in relation to a given amount of nitrogen fixed. If, then, the bean can in some way take up more nitrogen from the atmosphere than the wheat, the result must be due to character and function, rather than to mere extent of surface above ground. It may, however, be observed that, as a rule, even those of the leguminous crops which are grown for their ripened seed, maintain their green and succulent surface, over

a more extended period of the season of active growth, than do the gramineous corn crops.

It may safely be asserted, then, that neither direct experimental evidence, nor a consideration of the chemistry and the physics of the subject, would lead to the conclusion that the plants which assimilate more nitrogen over a given area than others, do so by virtue of a greater power of absorbing by their leaves combined nitrogen from the atmosphere in the form of ammonia. And here it may be said in passing that the argument would be still stronger against the supposition that nitric acid in the atmosphere supplies directly to the leaves of plants any important amount of the nitrogen they assimilate.

But apart from the more purely scientific considerations bearing upon the question, we believe that our statistics of nitrogen-production are themselves sufficient to justify the conclusion that, at any rate, the "broad-leaved" *root-crops*, turnips and the like, to which the function has with the most confidence been attributed, do not take up any important proportion of their nitrogen by their leaves from combined nitrogen in the atmosphere. Thus, it has already been shown, that the yield of nitrogen in these crops, even with the aid of complex mineral manures, was in the later years reduced to a lower point than that in any other crop; the percentage of nitrogen in the upper layers of the soil was also reduced to a lower point than with any other crop. The evidence of this kind is, however, admittedly not so conclusive in regard especially to plants of the leguminous family.

Is the free nitrogen of the atmosphere the source of the assimilated nitrogen?—But as about four-fifths of the atmosphere which surrounds the leaves of plants consist of free nitrogen, why should not this be a source to them of the nitrogen they require? To assume that it is so is such an obvious and easy way out of so many difficulties, that this assumption has from time to time been freely made, and much experimental investigation has been undertaken on the point with the most conflicting results. It is now nearly forty years since Boussingault showed that there was a greater assimilation of nitrogen over a given area in a rotation of crops than he could well account for; and almost from that time to this he has been occupied with investigations of very various kinds, sometimes on the atmosphere, sometimes on meteoric waters, sometimes on plants, and sometimes on soils, the main object of which has obviously been to throw light on the question of the sources of the nitrogen of vegetation. And almost for as long a period as Boussingault, Mr. Lawes and myself have devoted much thought and investigation to the same end.

On this point, of whether or not plants assimilate the free nitrogen of the atmosphere, leaving out of view, for lack of time and space, the experiments and conclusions of several others who have worked on the subject on a less comprehensive scale, I will first briefly direct attention to the most comprehensive series of experiments, the results of which led the author to conclude that the free nitrogen of the atmosphere is taken up and assimilated by the leaves of plants.

During the years 1849, 1850, 1851, 1852, 1854, 1855, and 1856, M. G. Ville, of Paris, made numerous experiments on this subject. His plants were generally enclosed in a glass case, and his soils consisted of washed and ignited sand, sand and brick, or sand and charcoal. They were sometimes supplied with a current of unwashed air, sometimes with a current of washed air, and they were sometimes in free air; sometimes a known quantity of ammonia was supplied to the air of the apparatus, and sometimes known quantities of nitrate were supplied to the soil. Lastly, a great variety of plants were experimented upon. M. G. Ville's results are summarized in Table V, below.

TABLE V.—*Summary of the Results of* M. G. VILLE'S *Experiments, to determine whether Plants assimilate free Nitrogen.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, and Air; and Manure, if any.	In Products.	Gain or Loss.	
1849: *Current of unwashed air supplying* 0·001 *grams Nitrogen as Ammonia.**				
Cress	0·0260	0·1470	0·1210	5·6
Large Lupins	0·0640	0·0640	0·0000	1·0
Small Lupins	0·0640	0·0470	—0·0170	0·7
	0·1550	0·2580	0·1030	1·7
1850: *Current of unwashed air supplying* 0·0017 *grams Nitrogen as Ammonia.**				
Colza (plants)	0·0260	1·0700	1·0440	41·1
Wheat	0·0160	0·0310	0·0150	1·9
Rye	0·0130	0·0370	0·0240	2·8
Maize	0·0290	0·1380	0·0990	4·4
	0·0857	1·2660	1·1803	14·8
1851: *Current of washed air.**				
Sunflower	0·0050	0·1570	0·1520	31·4
Tobacco	0·0040	0·1750	0·1710	43·7
Tobacco	0·0040	0·1620	0·1580	40·5

* Recherches Expérimentales sur la Végétation, par M. Georges Ville. Paris, 1853.

TABLE V.—*Continued.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, and Air; and Manure, if any.	In Products.	Gain or Loss.	
1852: *Current of washed air.**				
Autumn Colza	0·0480	0·2260	0·1780	4·7
Spring Wheat	0·0290	0·0650	0·0360	2·2
Sunflower	0·0160	0·4080	0·3920	25·5
Summer Colza	0·1730	0·5950	0·4220	3·4
Summer Colza	0·1050	0·7010	0·5960	6·7
1854: *Current of washed air (under superintendence of a Commission).*				
Cress	0·0099	0·0097	−0·0002	1·0
Cress	0·0038	0·0530	0·0492	13·9
Cress	0·0039	0·0110	0·0071	2·8
1854: *Current of washed air (closed, under superintendence of a Commission).*†				
Cress	0·0063	0·0350	0·0287	5·6
1855 and 1856: *In free air, with* 0·5 *grams Nitre* = 0·069 *Nitrogen.*‡				
Colza	0·0700	0·0700§	0·0000	1·0
Colza	0·0700	0·0660§	−0·0040	0·9
Colza	0·0700	0·0680§	−0·0020	1·0
1855 and 1856: *In free air, with* 1 *gram Nitre* = 0·138 *Nitrogen.*‡				
Colza	0·1400	0·1970§	0·0570	1·41
Colza	0·1400	0·3740§	0·2340	1·67
Colza	0·1400	0·2160§	0·0760	1·54
Colza	0·1400	0·2500§	0·1100	1·79
1856: *In free air, with* 0·792 *grams Nitre* = 0·110 *Nitrogen.**				
Wheat	0·1260	0·2180§	0·0920	1·7
Wheat	0·1260	0·2240§	0·0980	1·8
1855: *In free air, with* 1·72 *grams Nitre* = 0·238 *Nitrogen.**				
Wheat	0·2590	0·3080§	0·0490	1·2
1856: *In free air, with* 1·765 *grams Nitre* = 0·244 *Nitrogen.**				
Wheat	0·2650	0·2170§	−0·0480	0·8
Wheat	0·2650	0·3500§	+0·0850	1·3

* Recherches Expérimentales sur la Végétation, par M. Georges Ville. Paris, 1853.

† Compt. rend., 1855. ‡ Recherches Expérimentales sur la Végétation, 1857.

§ In plants only.

We have already discussed the results of M. G. Ville, as well as those of others, in a paper published in the Philosophical Transactions for 1859, and in a somewhat condensed form in the Journal of the Chemical Society, vol. xvi, 1863; and we can only very briefly refer to them in this place. The column of actual gain or loss of nitrogen is seen to show in one case a gain of more than one gram of nitrogen; the amount of it in the products being more than forty-one fold that supplied as combined nitrogen in the seed, and air. This result was obtained with colza. Those obtained with wheat, rye, or maize, showed very much less of both actual and proportional gain. Experiments with sunflower and tobacco showed a less actual gain than that with colza; but still it amounted in one case, with sunflower, to more than thirty, and in two, with tobacco, to more than forty-fold of that supplied. In M. G. Ville's experiments (as a glance down the last two columns in the table will show), although he still had generally some gain, it was usually both actually and in proportion to the quantity supplied considerably less than in his earlier ones.

M. G. Ville attributed the gain, in some cases, to the large leaf-surface. In explanation of the assimilation of free nitrogen by plants, he calls attention to the fact that nascent hydrogen is said to give ammonia, and nascent oxygen nitric acid, with free nitrogen, and he asks, "Why should not the nitrogen in the juices of the plant combine with the nascent carbon and oxygen in the leaves?" He refers to the supposition of M. De Luca, that the nitrogen of the air combines with the nascent oxygen given off by the leaves of plants, and to the fact that the juice of some plants (mushrooms) has been observed to ozonize the oxygen of the air, and he asks, "Is it not probable, then, that the nitrogen dissolved in the juices will submit to the action of the ozonized oxygen with which it is mixed, when we bear in mind that the juices contain alkalies, and penetrate tissues, the porosity of which exceeds that of spongy platinum?"

The experiments of M. Boussingault, and of ourselves, on the other hand, have not given an affirmative answer to the question whether plants, by their leaves, take up and assimilate free nitrogen of the air.

M. Boussingault commenced his experiments on this subject in 1837, and Table VI, which follows, summarizes his results, obtained at intervals from that date up to 1858.

TABLE VI.—*Summary of the Results of* M. BOUSSINGAULT'S *Experiments, to determine whether Plants assimilate free Nitrogen.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, or Plants; and Manure, if any.	In Products.	Gain or Loss.	
1837: *Burnt soil, distilled water, free air, in closed summer-house.**				
Trefoil	0·1100	0·1200	+0 0100	1·09
Trefoil	0·1140	0·1560	+0·0420	1·37
Wheat	0·0430	0·0400	−0·0030	0·93
Wheat	0·0570	0·0600	+0·0030	1·05
1838: *Conditions as in* 1837.†				
Peas	0·0460	0·1010	+0·0550	2·20
Trefoil (Plants)	0·0330	0·0560	+0·0230	1·70
Oats (Plants)	0·0590	0·0530	−0·0060	0·90
1851 and '52: *Washed and ignited pumice with ashes, distilled water, limited air, under glass shade, with Carbonic Acid.*‡				
Haricot, 1851	0·0349	0·0340	−0·0009	0·97
Oats, 1851	0·0078	0·0067	−0·0011	0·86
Haricot, 1852	0·0210	0·0189	−0·0021	0·90
Haricot, 1852	0·0245	0·0226	−0·0019	0·92
Oats, 1852	0·0031	0·0030	−0·0001	0·97
1853: *Prepared pumice, or burnt brick, with ashes; distilled water, limited air, in glass globe, with Carbonic Acid.*‡				
White Lupin	0·0480	0·0483	+0·0003	1·01
White Lupin	0·1282	0·1246	−0·0036	0·97
White Lupin	0·0349	0·0339	−0·0010	0·97
White Lupin	0·0200	0·0204	+0·0004	1·02
White Lupin	0·0399	0·0397	−0·0002	1·00
Dwarf Haricot	0·0354	0·0360	+0·0006	1·02
Dwarf Haricot	0·0298	0·0277	−0·0021	0·93
Garden Cress	0·0013	0·0013	0·0000	1·00
White Lupin	0·1827	0·1697	−0·0130	0·93
1854: *Prepared pumice with ashes, distilled water, current of washed air, and Carbonic Acid, in glazed case.*§				
Lupin	0·0196	0·0187	−0·0009	0.95
Dwarf Haricot	0·0322	0·0325	+0·0003	1·01
Dwarf Haricot	0·0335	0·0341	+0·0006	1·02
Dwarf Haricot	0·0339	0·0329	−0·0010	0·97
Dwarf Haricot	0·0676	0·0666	−0·0010	0·99
Lupin	0·0180	0·0334	−0·0021	0.94
Lupin	0·0175			
Cress	0·0046	0·0052	+0·0006	1·13

* Ann. Ch. Phys., II, lxvii, (1838).
† Ibid., lxix.
‡ Ann. Ch. Phys., III, xli, (1854).
§ Ann. Ch. Phys., III, xliii, (1855).

TABLE VI.—*Continued.*

PLANTS.	Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
	In Seed, or Plants; and Manure, if any.	In Products.	Gain or Loss.	
1851, '52, '53, and '54: *Prepared soil, or pumice with ashes; distilled water, free air, under glazed case.**				
Haricot (dwarf), 1851	0·0349	0·0380	+0·0031	1·09
Haricot, 1852	0·0213	0·0238	+0·0025	1·12
Haricot, 1853	0·0293	0·0270	−0·0023	0·92
Haricot (dwarf), 1854	0·0318	0·0350	+0·0032	1·10
Lupin (white), 1853	0·0214	0·0256	+0·0042	1·20
Lupin, 1854	0·0199	0·0229	+0·0039	1·15
Lupin, 1854	0·0376	0·0387	+0·0020	1·05
Oats, 1852	0·0031	0·0041	+0·0010	1·32
Wheat, 1853	0·0064	0·0075	+0·0011	1·17
Garden Cress, 1854	0·0259	0·0272	+0·0013	1·05
1858: *Nitrate of Potassium as Manure.*†				
Helianthus	0·0144‡	0·0130	−0·0014	0·90
	0·0255‡	0·0245	−0·0010	0·96

M. Boussingault's soils consisted of burnt soil, washed and ignited pumice, or burnt brick; his experiments were sometimes in free air, sometimes in a closed vessel with limited air, sometimes with a current of washed air, and sometimes in free air, but under a glass case. When the plants were enclosed, a supply of carbonic acid was provided, and in a few cases known quantities of nitre were supplied as manure.

The last two columns of Table VI show the actual and proportional gain of nitrogen in M. Boussingault's experiments. It will be observed that in his earliest experiments, those in free air, in a summer-house, the leguminous plants, trefoil and peas, did indicate a notable gain of nitrogen; but in all his subsequent experiments there was generally either a slight loss, or, if a gain, it was represented in only fractions, or low units, of milligrams. After twenty years of varied and laborious investigation of the subject, M. Boussingault concluded that plants have not the power of taking up and assimilating the free nitrogen of the atmosphere.

Our own experiments on this subject were commenced in 1857, and the late Dr. Pugh, of the Pennsylvania State Agricultural College, devoted between two and three years to the investigation at Rothamsted. Mr. Lawes has contributed one complete set of the apparatus employed to this exhibition. The arrangement, and the results obtained up to that date,

* Ann. Ch. Phys., Sér. III, xliii, (1855). ‡ Compt. rend., xlvii, (1858).
‡ Nitrogren in seed and nitrate.

are fully described in the papers already referred to, published in the Philosophical Transactions for 1859, and in the Journal of the Chemical Society in 1863. They may be briefly described as follows:—

The soils used were ignited, washed, and re-ignited, pumice, or soil. The specially made pots were ignited before use, and cooled over sulphuric acid under cover. The pots, with their plants, were enclosed under a glass shade resting in the groove of a specially made hard-baked glazed stone-ware lute-vessel, mercury being the luting material. Under the shade, through the mercury, passed one tube for the admission of air, another for its exit, and another for the supply of water or solutions to the soil; and there was an outlet at the bottom of the lute-vessel for the escape of the condensed water into a bottle affixed for that purpose, from which it could be removed and returned to the soil at pleasure. A stream of water being allowed to flow into a large stone-ware Wolff's bottle (otherwise empty), air passed from it through two small glass Wolff's bottles containing sulphuric acid, then through a long tube filled with fragments of pumice saturated with sulphuric acid, and lastly through a Wolff's bottle containing a saturated solution of ignited carbonate of soda; and, after being so washed, the air enters the glass shade, from which it passes, by the exit tube, through an eight bulbed apparatus containing sulphuric acid, by which communication with the unwashed external air is prevented. Carbonic acid is supplied as occasion may require, by adding a measured quantity of hydrochloric acid to a bottle containing fragments of marble, the evolved gas being passed through one of the bottles of sulphuric acid, through the long tube, and through the carbonate of soda solution, before entering the shade.

It will be observed that, by the arrangement described, the washed air is forced, not aspirated, through the shade, and the pressure being thus the greater within the vessel, the danger of leakage of unwashed air from without inward is lessened. In 1857, twelve sets of such apparatus were employed; in 1858 a larger number, some with larger lute-vessels, and shades; in 1859 six, and in 1860 also six. The whole were arranged, side by side, in the open air, on stands of brick-work, as described in the papers referred to, and shown in the apparatus exhibited. Drawings of some of the plants grown were also exhibited, and the published results are summarized in Table VII.

Table VII.—*Summary of the Results of Experiments made at Rothamsted, to determine whether Plants assimilate Free Nitrogen.*

			Nitrogen—Grams.			Nitrogen in Products to 1 Supplied.
			In Seed, and Manure, if any.	In Plants, Pot and Soil.	Gain or Loss.	
With NO *combined Nitrogen supplied beyond that in the seed sown.*						
Gramineæ.	1857.	Wheat	0·0080	0·0072	−0·0008	0·90
		Barley	0·0056	0·0072	+0·0016	1·11
		Barley	0·0056	0·0082	+0·0026	1·46
	1858.	Wheat	0·0078	0·0081	+0·0003	1·04
		Barley	0·0057	0·0058	+0·0001	1·02
		Barley	0·0063	0·0056	−0·0007	0·89
	1858. A*	Wheat	0·0078	0·0078	0·0000	1·00
		Oats	0·0064	0·0063	−0·0001	0·98
Leguminosæ.	1857.	Beans	0·0796	0·0791	−0·0005	0·99
	1858.	Beans	0·0750	0·0757	+0·0007	1·01
		Peas	0·0188	0·0167	−0·0021	0·89
Other Plants.	1858.	Buck Wheat	0·0200	0·0182	−0·0018	0·91
With combined Nitrogen supplied beyond that in the seed sown.						
Gramineæ.	1857.	Wheat	0·0329	0·0383	+0·0054	1·16
		Wheat	0·0329	0·0331	+0·0002	1·01
		Barley	0·0326	0·0328	+0·0002	1·01
		Barley	0·0268	0·0337	+0·0069	1·25
	1858.	Wheat	0·0548	0·0536	−0·0012	0·98
		Barley	0·0496	0·0464	−0·0032	0·94
		Oats	0·0312	0·0216	−0·0096	0·69
	1818. A*	Wheat	0·0268	0·0274	+0·0006	1·02
		Barley	0·0257	0·0242	−0·0015	0·94
		Oats	0·0260	0·0198	−0·0062	0·76
Leguminosæ.	1858.	Peas	0·0227	0·0211	−0·0016	0·93
		Clover	0·0712	0·0665	−0·0047	0·93
	1858. A*	Beans	0·0711	0·0655	−0·0056	0·92
Other Plants.	1858.	Buck Wheat	0·0308	0·0292	−0·0016	0·95

The upper part of the table shows the results obtained in 1857 and 1858 in the experiments in which no combined nitrogen was supplied beyond that contained in the seed sown. The drawings show how extremely restricted was the growth under these conditions, and the figures in the table show that neither with the Gramineæ, the Leguminosæ, nor with buckwheat, was there in any case a gain of three milligrams of

* These experiments were conducted in the apparatus of M. G. Ville.

nitrogen indicated. In most cases there was much less gain than this, or a slight loss. There was in fact nothing in these results to lead to the conclusion that either the Gramineæ, the Leguminosæ, or the buckwheat had assimilated free nitrogen.

The lower part of the table shows the results obtained in 1857 and 1858, in the experiments in which the plants were supplied with known quantities of combined nitrogen in the form of a solution of ammonium sulphate applied to the soil. The gains or losses range a little higher in these experiments, in which larger quantities of nitrogen were involved, but they are always represented by units of milligrams only, and the losses are higher than the gains. Further, the gains, such as they are, are all in the experiments with the Gramineæ, while there is in each case a loss with the Leguminosæ, and with the buckwheat. On this point it should be stated that the growth was far more healthy with the Gramineæ than with the Leguminosæ, which are even in the open fields very susceptible to the vicissitudes of heat and moisture, and were found to be extremely so when enclosed under glass shades. It might be objected, therefore, that the negative result, with the Leguminosæ are not so conclusive as those with the Gramineæ. However this may be, taking the results as they stand, there is nothing whatever in them to lead to the conclusion that either the Gramineæ or the Leguminosæ can take up and assimilate the free nitrogen of the atmosphere. We, indeed, do not hesitate to conclude from our own experiments, as Boussingault did from his, that the evidence is strongly against the supposition that plants can so avail themselves of the free nitrogen of the atmosphere.

Independently of the action suggested as possible by M. G. Ville, that is between free nitrogen and nascent or ozonized oxygen within the plant itself, it has been supposed that the free nitrogen of the atmosphere may unite with the nascent oxygen, or ozone, as the case may be, evolved by the plant, and so yield nitric acid. In our papers above referred to we have given reasons for supposing that such actions are not likely to take place; but whether they do or do not, it is at any rate certain that in our own experiments we have not been able to persuade plants to avail themselves of this happy faculty of producing their own nitrogenous food. With regard to the action supposed possibly to take place externally to the plant itself, if it were in any material degree operative, we should expect some, at least, of the resulting combined nitrogen to be collected in the aqueous deposits from the atmosphere; but we have seen how inadequate is the amount of combined nitrogen in those deposits to account for the yield of nitrogen, even of the Gramineæ, and still less can it satisfactorily explain the yield in the Leguminosæ and other plants.

[To be continued.]

ART. XII.—*On the Orbit of the planet Urda* (167); by C. H. F. PETERS.

THIS planet was discovered as a star of 12th magnitude on August 28th ult., and the observations obtained, after applying corrected star positions, are the following, each being the mean from twelve comparisons by ring-micrometer.

1876.	Ham. Col. m. t.			App. α (167).			App. δ (167).		
	h	m	s	h	m	s	°	′	″
Aug. 28,	14	18	21	21	58	32·22	−11	23	41·2
" 30,	13	35	16	21	57	2·27	−11	33	23·3
Sept. 12,	12	48	43	21	48	16·70	−12	31	14·2
" 15,	12	19	28	21	46	38·63	−12	42	24·8

It seems that the planet has not been seen anywhere else; and the orbit therefore had to be evolved from the foregoing observations alone, however unequally distributed over an interval of only eighteen days. I succeeded by computing first a circular orbit, which served for freeing the observations from aberration and parallax, and then using of the eight data the four longitudes and the two extreme latitudes. The final ellipse arrived at is the following:

Epoch, 1877, Jan. 0·0 Berlin m. t.

$L = 317° 43′ 27·4″.$
$\pi = 32° 39′ 22·2″ + 50·24″ (t. - 1876).$
$\Omega = 170° 7′ 25·4″ + 49·25″ (t. - 1876).$
$i = 1° 42′ 14·5″ - 0·47″ (t. - 1876).$
$\varphi = 18° 10′ 30·6″.$
$\mu = 614·475″.$
$\log a = 0·507668.$

Of these elements, three, viz., node, inclination and major axis, bear a remarkable resemblance to those of Gerda (122). Moreover, the element of the excentricity, as it is derived from so short an arc in our orbit, remains necessarily very uncertain. The same is the case, though in less degree, and for the same reason, with the position of the apsides, or the longitude of perihelion. Only the remaining 6th element, therefore, can decide, whether the two planets are identical. Now, for the same epoch we have for Gerda $L = 168° 46′$, and as the correctness of Mr. Stockwell's computations of Gerda are fully confirmed by observations upon this planet made at Berlin in April last, it is proved that Urda is distinct from Gerda.

The fact of two planets moving in the same plane, with the same time of revolution, having also the line of apsides in common (our elements, if correct, show a longitude of perihelion nearly 180° distant from Gerda's), but with a widely different

excentricity, is worthy of note. And it is therefore still more desirable, that Urda should not pass unnoticed in its next opposition, which will occur in January, 1878, and when the planet will be of the 12·7 magnitude.

Litchfield Observatory of Hamilton College, Jan. 6, 1877.

ART. XIII.—*Principles of Compensation in Chronometers;* by J. B. JAMES, M.D., Trenton, N. J.

"FOR one to know, is nothing, unless others also may know," is an aphorism of modern progressive science; for it is only from what has been attained that step by step further progress may be made. This it is which impels the writer to offer some considerations on the principles of compensation in chronometers.

It may be assumed as an axiom of general application, that an error should be avoided whenever it is possible, rather than compensated; yet this plain axiom is disregarded in the compensation balance, in two respects.

1st. What is the action of the laminated rim as affected by change of temperature? The end of the arm is commonly regarded as a fixed point, which it is not; for its distance from the center is changed by change of temperature; and whatever weight is here, if its distance from the center is changed, that change must be compensated at the other end of the segment; and therefore this is not the place for mean-time screws; while between these two ends of the segment, there must be a point whose distance from the center undergoes little or no change, and where its weight requires no compensation for change of temperature. This point of uniform distance from the center, when ascertained, should therefore be regarded as the *fixed point;* and if the compensation required were only for the changes in the balance itself, it would be absolutely perfect; for as the one end of the segment recedes from the center, the other approaches it—the one merely taking the place of the other; and this would be in effect true whether the ends were equidistant from the fixed point or not—the longer segment requiring only the less weight. It is the attempt to compensate, in the balance, for changes in the length and elasticity of the spring that creates the necessity for a *secondary* compensation.

This principle of compensation for temperature has been practiced in the pocket chronometer, with marked success, by Henry B. James, of Trenton N. J., for some years. He attaches the outer end of the balance spring to the elastic arm of a laminated convolute, which, at the same time that it compensates, more or

less, for changes in the spring, permits a more free movement of the balance; while, parting the rim of a balance having equal thicknesses of brass and steel in its structure, at a distance of one-sixth of its circumference from the arm, he assumes the middle of the longer portions, and the free ends of the shorter, as places where weight requires no compensation, the longer portions carrying on their free ends only a moderate weight for the compensation needed.

2d. The work performed by the balance near its center of motion is a source of error that has been generally neglected. It is a settled principle of dynamics, that "if a body revolving on an axis strike an immovable obstacle at the *center of percussion*, the point of suspension will not be affected by it;" while "if the blow be struck in any other point, a part of its motion will be employed in endeavoring to continue the motion." Thus if we take into the hand at one end a club of uniform thickness, and by a motion from the wrist as a center strike an obstacle at a distance of one-third its length from the other end, the hand feels no effect from the blow; but if it be struck by any other point, the hand will receive a part of the blow,—greater as it is further from the point named. Now the "center" or *line* of percussion of a balance is in or near the rim, and the resistance to its motion, by means of the spring and escapement, is near its center; and the force thus lost, as to the movement of the spring and escapement, is transmitted to the pivots of the balance as useless friction. The errors arising from the relative positions and directions of these forces and that of gravitation, and the changes therein from change of position or latitude, from the density of the air and the space in which the balance moves, varying friction from the oil, lurches on shipboard or jolts in the pocket, and from the different rates of expansion of metals as they affect the friction of the balance or pivots or the working of the escapement—these furnish a problem to ascertain or compensate their average effects, sufficiently complicated to account for the little progress that has been made in perfecting the chronometer. For however small may be their effects on a single movement of the balance, when it is multiplied by fourteen to eighteen thousand for every hour, or three or four hundred thousand in twenty four hours, they become so readily appreciable as to deserve attention and amelioration.

Now if we can remove from the balance pivots this intermittent and useless friction, leaving only its own greatly reduced and uniform amount, unchanged by change of position or temperature, a balance of greater momentum could be substituted, which, in a proportionate degree would lessen the effect of the remaining sources of error, and this, it is believed, can be accomplished by simple and practicable mechanism.

Art. XIV.—*Notes on the Vespertine Strata of Virginia and West Virginia;* by William M. Fontaine.

(Concluded from page 48.)

Vespertine of Augusta and Rockingham Counties.

My principal examinations in this quarter were made at "North River Gap," in the northern corner of Augusta county, in the "Dora Coal Field." In this part of the State the eastern edge of a fractured portion of the Vespertine area seems to have been pressed down against the massive Lower Silurian limestone, along the line of fault which runs on the west side of the "Valley of Virginia." This has resulted in the overturn of the strata westward, and the catching of a narrow synclinal belt of the middle member under the massive sandstones of the lower portion. These, by their resistance to erosion, have preserved from removal the more destructible strata of the coal-bearing rocks, and standing up in huge ribs, form the core of the Great North Mountain, here called locally, "Narrow Back." As might be expected, especially in the mountain itself, the amount of contortion and crushing is immense.

The sandstones are changed to quartzites, with all granular structure obliterated. The shales which contain the coal, from their more yielding nature, have suffered most. Where they are exhibited in the western face of the mountain, they are thrust through the coal seams, and wrapped in the most complicated contortions. In places they seem to have been drenched with water holding silica in solution. They sometimes contain lumps and strings of quartz, deposited by such waters. Yet with all this, they are true shales, being rendered only more compact and harder. This is another striking example of the difference in the amount of metamorphic action, produced in sandstones and shales, when subjected to the same influences, and of the insufficiency of mechanical disturbance to produce more than the first stages of metamorphism.

The convoluted and disturbed strata of the mountain dip southeast at a high angle. After passing it to the west, the dip flattens rapidly, and while the rocks of the mountain are inverted, we now find them in their normal position. We may compare the structure of the belt to a fish-hook, with its shank turned westward, the bend representing the mountain. The material of the hook would represent the sandstones of the lower Vespertine, while we may conceive the middle member with its coals as filling the curve, and resting upon the shank. It will thus be seen that the number of coal beds will be doubled by overlap in the west face of the mountain. The

strata have suffered much from erosion, and show only the lower and middle members. It is however by no means certain that the upper member of red shales was ever present. The increase in the coarseness and amount of the sandstones underlying the coal strata seems rather to indicate its former absence. No limestone appears here.

I did not make a complete section at this point of the strata supposed to represent the Catskill. Enough however was seen to show that red shales appear here at the same horizon as at Lewis Tunnel, but the amount is not so great, and they are now changed to red argillaceous flags. The upper members here are somewhat massive liver-colored sandstones, which graduate upward into the white sandstones of the lower Vespertine. The Catskill? strata seem to be considerably thicker in this region than at Lewis Tunnel.

The sandstones of the lower member of the Vespertine cannot be separated by any distinct dividing line from the above mentioned rocks. But, assuming for their base the strata which do not show a predominance of the red color, they show a thickness of about 400 feet. All are highly siliceous, and lie in pretty massive beds. No dividing line can be drawn in this mass of rock, but a gradual change may be traced. At the base it is brownish gray, then gray, and finally white, passing near the top into gray flags. The white portion is about 200 feet thick, being mainly a massive quartzite, but showing in the lower portion some conglomerate bands. Over the above mentioned rocks are about 40 feet of gray flags, in the top of which is the lowest coal bed. This stratum may be taken as the lower portion of the middle member. The following is the section from the lowest coal ascending to the highest:

1. Black siliceous shales, (floor).
2. Coal, 18 inches.
3. Argillaceous sandstone, 4 feet.
4. Black siliceous shale, 6 inches.
5. Sandstone, 8 inches.
6. Black siliceous shale, 4 feet.
7. Sandstone, 1 foot.
8. Black shale, 5 feet.
9. Coal, 2–2½ feet.
10. Black siliceous shale, 12 ft.

No. 2 is very impure, and where it is best has several partings of shale. It is very variable in the amount of coal, and often runs almost entirely into shale. No. 6 has some thin strings of coal, as is the case with No. 8. No. 9 is the most constant bed, and has the largest amount of clear coal. In the top of No. 10 a few thin strings of coal sometimes occur.

The remaining rocks above No. 10 are gray and bluish-gray sandy shales, showing in some places abundant plant impressions. The exposures are too poor to allow any approximation to their thickness.

The coal here is a true anthracite, of pretty good quality. Attempts have been made, from time to time, to work it, but

without success. The large amount of carbon in some of the shale immediately associated with the coal, its highly glazed aspect (from friction), and the intimate manner in which it is mixed with the true coal, have led to an exaggerated estimate of the thickness of the beds. This mistake was aided by the imperfect manner in which the coal was exposed in the outcrops. From these causes I was myself led, some two years ago, on my first visit to the place, to think the amount of coal greater than it has proved to be. Of late the somewhat extensive exploration made in this field by the Royal Land Co., of Virginia, has demonstrated that the amount of coal is too small, and its crushing too great, to render it of commercial value.

The Vespertine strata in Montgomery County.

I have not had the good fortune to procure a copy of Prof. Lesley's "Description of the South Virginian Coal Region of Montgomery and Wythe counties," published in vol. ix, Proc. Am. Phil. Soc. No doubt this would have aided me greatly in my study of the Vespertine of Montgomery, to which my investigations were confined.

The Vespertine strata in Montgomery county occupy two distinct areas, which require separate descriptions. The most important of these is the narrow tract lying on the northern side of the great fault, which passes just south of Brush Mountain. This is but the continuation, to the south, of the belt just described in Augusta county.

The smaller area lies about two miles south of Brush Mountain, from which it is separated by a narrow belt of Lower Silurian limestone, and about two and a half miles northwest of Christiansburg. This small area, so far as I know, has never received the notice that it deserves. Prof. Rogers simply speaks of it as an outlier of Vespertine, similar in character to that of Brush Mountain. But little was known of it then, and even up to the late war, when its coals were examined and worked to some extent. Since then the good quality and thickness of the beds, as well as the ease with which they may be worked, have led to their farther development.

The structure of this field, which bears the name of Price's Mountain, is one of the most curious products of the force which has produced the numerous faults in this region. It is a belt, with an anticlinal structure, about seven miles long, and $2\frac{1}{2}$ wide, running nearly east and west, (more accurately, 10° N. of E.).

The maps of Virginia show a mountain chain, under the name Alleghany, running by Christiansburg in a northerly direction, to meet Brush Mountain. This is merely a watershed, and does not appear above the surrounding country as

mountain. The eastern end of the Vespertine belt in question is found in this watershed. From that point, where the strata stand at the general level of the country, they run nearly in a westerly direction toward New River, and pass about 2½ miles northwest of Christiansburg. The strata of the eastern end are the red marlites of the upper member. In passing westward they begin to rise into an anticlinal elevation, which soon attains the height of about 300 feet, which height is maintained for about 3½ miles, showing a continuous ridge. This portion bears the name of Price's Mountain. Farther west, toward the river, the ridge is broken up into hills, and then finally disappears before the stream is reached. I am informed that no trace of the strata is to be found west of New River, where the rock is all limestone.

As the ridge rises in passing west, the coal-bearing strata of the middle member begin to appear through the red marlites, and where it is highest, the upper part of the lower member appears in the crest. In this portion the coals are worked. Here we find the red marlites forming an outer band on each side of the ridge, and cut off abruptly north and south by the Lower Silurian limestone, which also sweeps around the eastern end. The coal strata occupy the foot, and reach some distance up the slope, on each side. The field seems to be a prism of Vespertine strata, engulfed by a double fault in the limestone, with its eastern end tipped lower than the middle and western portions. The dip of course is nearly north and south, away from the crest, and toward the limestone.

The amount of contortion and rubbing exhibited by the strata is surprisingly small. The roof and floor of the openings made are as uniform and smooth as those of our upper coals of the West. As a consequence, the coal is worked with ease, and unlike that of Brush Mountain, two miles off, shows but little rubbing, and may be taken out in blocks of any size. There are two beds here as in Brush Mountain, being evidently the same. The amount of slate partings is however smaller in Price's Mountain, and the coal thicker.

As the middle member containing the coal beds is evidently similar to that exposed in Brush Mountain, while the exposure here is not so good, the section of it taken in that mountain will suffice for both localities. The same may be said of the lower member. The upper red beds however are much better displayed here, and the section of them, taken from the northern foot of Price's Mountain northward to the limestone, will be given as a representative one. We find here these rocks well exposed, with a steady northward dip, until they are suddenly cut off by the limestone.

The dip on the north side is somewhat steeper than on the

south side, being in the former case 30° N.N.W., and in the latter, 26° S.S E. The coal of the upper bed on the north side is somewhat thicker than that on the south side. The lower bed is essentially the same on both sides. The lower bed everywhere averages about two feet. It is enclosed in gray flags. and separated from the upper by about forty feet of the same kind of rock.

An average section for the upper bed on both sides, is as follows, commencing at the top:

1. Black slate, (roof).
2. Coal, 12 inches.
3. Slate, 12 inches.
4. Coal, 2½ feet.
5. Slate, 7 inches.
6. Coal, 10 inches.
7. Slate, (floor).

No. 4 sometimes runs up to three feet, and the other layers of coal show occasionally an increase of several inches in thickness.

The following section, omitting details, will give the character of the red upper member, commencing below:

1. Interstratification of brown sandstone, and red shale, 50 feet.
2. Red and mottled marlites, with some brown sandstone, 440 ft.
3. Thinly fissile, red shales, " " " " 600 feet.

A regular change may be traced in the character of these sediments. No. 1 and No. 2, in the lower portion, have a larger proportion of sandstone. But in the greater portion of No. 2, especially the middle and upper parts, and in all of No. 3, the sandstone appears only in occasional beds. The lower portion of No. 2 is often mottled with spots and streaks of gray and green. The indications are that the strata were deposited during a steadily progressing subsidence.

This thickness of 1090 feet of red shales and marlites is suddenly cut off on the northern side, by the Lower Silurian limestone, which throughout this region has a southeast dip, and shows a considerable amount of alteration. No remnant of the Lower Carboniferous, or Lewisburg limestone, is seen here, and if it were ever present, it has been removed by erosion. It is clear that this mass of red strata was deposited prior to this limestone, if it were ever formed here. In any case we would have a great development of the upper member, as compared with the same near Lewis Tunnel, and this agrees well with the development of the two underlying members in this region.

I am inclined, however, to think that all of these beds were not deposited before the limestone. The increasing fineness of the upper portion No. 3, and other indications that this part was formed in comparatively deep and quiet waters, make it quite probable that No. 3 is the representative here of the limestone. So far as I know the limestone has been seen by no one so far to the east. The sudden cutting off of the Lower Carboniferous

limestone by faults in its most easterly known exposures, renders it difficult to draw any conclusions from a change of thickness.

Brush Mountain lies to the north of Price's Mountain, and is separated from it by a belt of Lower Silurian limestone about 1½ miles wide. Its structure is very simple. The northern foot is composed mainly of Chemung strata, while the central mass is formed of the lower member of the Vespertine, which extends some distance down the southern slope. A portion of the southern face and foot of the mountain is composed of the middle or coal-bearing member, while a band of red rocks belonging to the upper member forms the foot-hills next to the limestone belt. By the great fault, mentioned before as running on the western side of the valley of Virginia, this mass of strata has been brought down so as to abut against the Lower Silurian limestone. Though there has been no overturn of the strata, yet some slight shifting of the beds has been produced, causing a considerable amount of rubbing and crushing. This has made itself felt, especially in the coal, which in consequence is much more fractured and rubbed than that of Price's Mountain, yet by no means so much so as that of Augusta and Rockingham counties. Poverty Creek, after flowing for some distance along the north side, cuts directly through this mountain, and gives a good section of all the strata of the Vespertine. The dip is 30° S.S.E. toward the fault. My section was taken along this creek, commencing on the north side in the Chemung beds, and proceeding south to the upper member of the Vespertine.

The Chemung beds show the same character here as at Lewis Tunnel. The same alternations of flaggy sandstone and shales, with thin layers containing numerous impressions of shells, are found. These beds are to be seen within a space of 400 feet, under the lowest of the Vespertine strata. This interval was too much concealed to enable me to determine whether it is occupied by Chemung beds, or strata which may be the equivalents of the Catskill. If the latter are present here, they must be less than 400 feet thick. I am inclined to think that they are entirely absent, having been replaced by the greatly thickened lower beds of the Vespertine. The following is the section of the latter in ascending order.

Lower member of the Vespertine.

1. Massive white conglomerate and sandstone, 80 feet.
2. Massive white sandstone, with layers of conglomerate, 150 feet.
3. Thin-bedded white siliceous sandstones, 100 feet.
4. White and yellowish flags, marked with red spots and streaks, 300 feet.
5. Siliceous gray sandstones and flags, 300 feet.

Total for the lower member, 930 feet.

No. 1 is a conglomerate of remarkable coarseness, and contains only subordinate bands of coarse white sandstone. Most of the pebbles are from a half an inch to an inch in size, but many are two inches in diameter, and flat. The quartzose matter is all pure white, and plainly derived from the Potsdam and underlying quartzites, as may be easily seen from the nature of the larger pebbles. The smaller pebbles are rounded. The great coarseness, pure siliceous character, and white color of this stratum, contrast in the most striking manner with the underlying Chemung beds, and point to a radical change in the conditions of deposition.

No. 2 is a highly siliceous, white sandstone, with subordinate bands of smaller pebbles. A gradual change from a highly siliceous character to a more argillaceous one, may be traced as we ascend in the series. No. 4 is marked with streaks and spots of red, and begins to show some argillaceous matter, especially toward the top, while in No. 5 a large amount of this material is present. This latter is heavy bedded toward the bottom, and more flaggy toward the top.

Middle member of the Vespertine.

1. Argillaceous gray sandstones, 200 feet.
2. Coal. Upper bed, thickness not exposed.
3. Massive and flaggy gray sandstones, interstratified, 120 feet.
4. Bluish, argillaceous gray flags, 350 feet.

Total for the middle member, 670 feet.

The lower coal-bed was not seen in this section. No. 3 is rather more massive and siliceous here than in Price's Mountain. In No 4, occasional beds 10 to 15 feet thick occur, more massive and siliceous than the great body of the mass. Next above No. 4 come the red beds of the upper member.

The coals of Brush Mountain lie in two beds, identical with those of Price's Mountain, but, as stated before, the amount of slate partings is greater, as is the disturbance to which they have been subjected. Still the upper bed here is also worked to a considerable extent. The lower bed has a sandstone floor and roof. It is about three feet thick, with a slate parting in the middle, from five to ten inches thick. This bed was formerly worked on a small scale, but is now entirely neglected. The upper bed is separated from this by from thirty-five to forty feet of gray flags. About half way between the two, at some of the openings, a small seam twelve inches thick, is reported to exist. The following is the section of the upper bed:

No. 1. Bottom slate.	No. 4. Coal, 6 inches.
" 2. Coal, 8 inches.	" 5. Slate, 1 inch.
" 3. Slate, 3 inches.	" 6. Coal, 6 inches.

No. 7. Slate, 10 inches.
" 8. Mining dirt, 6 inches.
" 9. Main coal, 20–30 inches.
" 10. Slate, 8 inches.
No. 11. Slaty coal, 6 inches.
" 12. Mining dirt, 6 inches.
" 13. Coal and slate, 20 inches.
" 14. Coal, 10 inches.

No. 2 is quite soft, and a good material for blacksmiths. The "bearing in" is done in Nos. 8 and 12. These are composed of crushed coal and slate. All the material above and below them is neglected. The roof above No. 14 is a coarse sandstone with some pebbles. In some localities two small seams occur above this bed, within the space of forty-five feet. These small seams may occur in Price's Mountain, but were not seen.

The coal is all semi-bituminous, some of it approaching an anthracite. The coal of the lower bed is harder than that of the upper. In Price's Mountain the coal of the main portion of the upper bed is a handsome, firm material, with a dull lustre, much resembling the natural coke of the Richmond coal field. It seems here to be remarkably free from sulphur. The coal of Brush Mountain is usually glazed by friction, and seems to have more sulphur. An analysis by Prof. Rogers makes these coals to contain: 14 p. c. bituminous matter, 80 p. c. carbon, and 6 p. c. of ash. The ash is very fine, and of a white color. The coal is said to be excellent for grates and stoves.

It will be seen from the above account that there has been a very marked thickening of the Vespertine as we proceed from north to south through the state, accompanied by an increase in the amount of coal contained in it. This increase seems to be largely at the expense of the supposed Catskill beds. It is in conformity with a law of increase which holds good for all the strata from the Devonian to, and including, the Lower Barren Measures of the Upper Coals.

Plants.

I have, whenever opportunity offered, made a collection of the plant impressions, but owing to their peculiar mode of distribution, and the small amount of excavation made in these strata, I have, as yet, not been able to procure a collection large enough to be offered as representative of the series. Hence I will not attempt to give here anything but a few general statements, which may be greatly modified by farther discoveries.

So far as my observations go, the plants of this series of strata occur at any given locality, with but few species, while these are marked by the great number of individuals which they exhibit. These species are widely distributed, and perfectly characteristic of the series, at least as compared with the flora of the beds above the Conglomerate. The most important and characteristic plants are the following:

1. *Lepidodendron.* The forms of Lepidodendron are the most abundant and widely distributed. They are all characterized by small leaf-scars.

2. *Palæopteris.* This shows two types. By far the most abundant and widely distributed is the form with narrow elliptical leaflets, like *P. Jacksoni.* We find much less abundantly, a second type with broad flabellate leaflets, like *Palæopteris obtusa.*

3. *Triphyllopteris.* To this, I consider Mr. Meek's *Cyclopteris Virginiana*, and *C. Lesueuriana*, as belonging. The latter plant, with possibly a similar species, is widely distributed and very abundant in some localities, forming all the impressions to be found.

I have nowhere seen any impressions of Sigillaria, Calamites, Sphenopteris, and others of the most common plants in the productive coal-measures. In only one case have I seen a specimen of Neuropteris, and this was a remarkably fine one, of *N. flexuosa*, found at Lewis Tunnel. This place has yielded a much greater variety of plants than any other locality visited by me. Of course this negative evidence, in the absence of extended exploration, cannot be taken as excluding the former presence of these plants in the Vespertine. Still it is peculiar that with the many hundreds of specimens seen at widely distant localities, none of those plants noted above as not seen, should have been met with.

ART. XV.—*Contributions from the Sheffield Laboratory of Yale College.* No. XLI.—*On the Chemical composition of the flesh of Hippoglossus Americanus;* by R. H. CHITTENDEN.

THE *Hippoglossus Americanus* of Gill, or halibut as the fish is commonly called, is found in the waters of the Atlantic ocean from Newfoundland to Cape Hatteras. The halibut belongs to the class of white-blooded fish, of which the *Merlangus vulgaris*, or whiting, is a typical representative. The flesh of the halibut is of a fine white color, quite delicate and tender, and is highly valued for food, especially in certain portions of the United States.

A fresh sample obtained at the market yielded by analysis

	No. 1.	No. 2.
Water	82·85	82·90
Solids	17·15	17·10
Ash	1·08	1·08
Fat	1·21	1·32
Nitrogen	2·02	2·00
Phosphoric acid (P_2O_5)	·37	

The fresh flesh of the whiting yielded Payen*—

Water	82·95
Solids	17·05
Ash	1·08
Fat	·38
Nitrogen	2·41

According to Pavy the flesh of the whiting which is eaten so extensively in England, is tender, easily digested, and highly nutritious. A comparison of these two analyses shows but very little difference in the chemical composition of the flesh of the halibut and whiting.

The flesh of the halibut dried at 100° C. yielded by analysis:

	No. 1.	No. 2.
Carbon	50·30	50·46
Hydrogen	7·36	7·51
Nitrogen	11·70	11·66
Ash	6·32	6·39
Oxygen	24·32	23·98
	100·00	100·00
Fat	7·08	7·15

The ash of the flesh gave by analysis:

Silica	·32
Chlorine	11·11
Carbonic acid	1·13
Sulphuric acid	1·30
Phosphoric acid	34·36
Iron	·19
Lime	·15
Magnesia	2·43
Potash	37·07
Soda	12·22
Lithia	trace
	100·28

The ash for the analysis was obtained by carbonizing a large quantity of the flesh, then leaching this carbonized mass with hot water to remove chlorides. The residue left undissolved by the water was then ignited at a higher temperature until burned white. The aqueous solution of the chlorides was then poured over the insoluble residue and the whole heated until the water was completely driven off. This residue was ignited gently and yielded a perfectly white ash.

By a backward glance at these analyses we see that the food value of the flesh of the halibut is not of a low order, but compares favorably with the flesh of other fish of the same class.

* Compt. Rend., xxxix, 318.

ART. XVI.—*Notice of Darwin on the Effects of Cross- and Self-Fertilization in the Vegetable Kingdom;** by ASA GRAY.

MR. DARWIN, in the title of his new work, refers only incidentally to adaptations for cross-fertilization,—a subject which has given origin to a copious literature since he opened it anew in his book on the Fertilization of Orchids, in 1862. A new edition of this latter book is on the eve of publication in England, and we believe that this author's scattered papers on cross-fertilization, as secured by various contrivances, are about to be collected, revised, and issued in a book form. In the volume now before us, Mr. Darwin deals with the effects of cross- and self-fertilization, recounts at length the experiments he has devised and carried on, collects and criticises the results, glances at the means of fertilization, and the habits of insects in relation to it, and ends with some theoretical considerations or inferences suggested by or deduced from the facts which have been brought to light.

If writing for the popular press, we should be bound to say that this book is not light reading. Three-fourths of its pages and of the chapters are devoted to the details of the experiments and the sifting and various presentation of the results; and the remainder, although abounding in curious facts and acute suggestions, is yet of a solid character. The bearings of various points upon what is called "Darwinism" are merely touched or suggested, here and there, in a manner more likely to engage the attention of the thoughtful scientific than of the general reader.

That cross-fertilization is largely but not exclusively aimed at in the vegetable kingdom, is abundantly evident. As Mr. Darwin declares, "it is as unmistakably plain that innumerable flowers are adapted for cross-fertilization, as that the teeth and talons of a carnivorous animal are adapted for catching prey, or that the plumes, wings, and hooks of a seed are adapted for its dissemination." That the crossing is beneficial, and consequently the want of it injurious, is a teleological inference from the prevalence of the arrangements which promote or secure it,—an inference the value of which increases with the number, the variety, and the effectiveness of the arrangements for which no other explanation is forthcoming. That the good consisted in a re-invigoration of progeny, or the evil of close-breeding in a deterioration of vigor, was the suggestion first made (so far as we know), or first made prominent, by Knight, from whom Darwin adopted it. However it be as to animals, there

* The Effects of Cross- and Self-Fertilization in the Vegetable Kingdom; by CHARLES DARWIN, M.A., F.R.S., etc. London: Murray. (New York: D. Appleton & Co.) 12mo, pp. 482. 1876.

was until now no clear and direct evidence that cross-fertilization in the vegetable kingdom did re-invigorate. Indeed, the contrary might be inferred from the long and seemingly indefinite perpetuation of bud-propagating varieties, which have no fertilization at all. But the inference from this is not as cogent as would at first appear. For, although bud-propagation is, we think, to be considered as the extreme of close-breeding, yet in it the amount of material contributed by parent to offspring is usually vastly more than in sexual reproduction: and, accordingly, the diminution to an injurious degree of any inherited quality or essence might be correspondingly remote. Yet, as sexual reproduction may be and often must be much closer in plants than it can be in most animals, the ill effects of self-fertilization, or the good of cross-fertilization, might the sooner be noticeable. Mr. Darwin arranged a course of experiments to test this question, prosecuted it as to some species for eleven years; and the main object of this volume is to set forth the results.

Ipomœa purpurea, the common Morning Glory of our gardens, was the leading subject. The flowers of this species self-fertilize, but must also be habitually cross-fertilized, as they are visited freely by humble-bees and other insects. Ten flowers of a plant in a greenhouse were fertilized with their own pollen; ten others were crossed with pollen from a different plant. The seeds from both were gathered, allowed to germinate on damp sand, and as often as pairs germinated at the same time the two were planted on opposite sides of the same pot, the soil in which was well mixed, so as to be uniform in composition. "The plants on the two sides were always watered at the same time and as equally as possible, and even if this had not been done the water would have spread almost equally to both sides, as the pots were not large. The crossed and self-fertilized plants were separated by a superficial partition, which was always kept directed towards the chief source of the light, so that the plants on both sides were equally illuminated." Five pairs were thus planted in two pots, and all the remaining seeds, whether or not in a state of germination, were planted on the opposite sides of a third pot, so that the plants were crowded and exposed to a very severe competition. Rods of equal diameter were given to all the plants to twine up, and as soon as one of each pair had reached the summit, both were measured. But a single rod was furnished to each side of the crowded pot, and only the tallest plant on each side was measured. This was followed up, for ten generations; the close fertilization being always self-fertilization, i. e., by pollen to stigma of the same flower; the crossing, between individuals in successive generations of this same stock, except in special instances,

when an extraneous stock was used as one parent,—to eminent advantage, as will be seen.

The difference in vigor between the cross-bred and the close-bred progeny, as measured by early growth, was well marked throughout. In the mean of the ten generations it was as 100 to 77. In the tenth generation it was 100 to 54, that is, five cross-bred plants grew to the average height of 93·7 inches while the close-bred were reaching the average of 50·4 inches. This was a notably greater difference than in any previous generation. But this was probably accidental or anomalous; for it was not led up to by successive steps. Indeed, the difference in the first generation was a trifle greater than the average of all ten, being as 100 to 76. The second generation was as 100 to 79; the third as 100 to 68; the fourth as 100 to 86; the fifth as 100 to 75; the sixth as 100 to 72; the seventh as 100 to 81; the eighth as 100 to 85; the ninth as 100 to 79; the tenth, as already stated, 100 to 54. The general result is made striking in the following illustration.

"If all the men in a country were on an average six feet high, and there were some families which had been long and closely inter-bred, these would be almost dwarfs, their average height during ten generations being only four feet eight and one-quarter inches." (p. 53.)

It is remarkable that the difference between the close-bred and the cross-bred individuals should have been as great as it was in the first generation; and, this being the case, it might have been expected that the difference would have gone on increasing in the succeeding generations. If self-fertilization is injurious, the ill effects would be expected to be cumulative. "But," instead of this, "the difference between the two sets of plants in the seventh, eighth, and ninth generations taken together is less than in the first and second generations together." Upon this Mr. Darwin remarks: "When, however, we remember that the self-fertilized and crossed plants are all descended from the same mother plant, that many of the crossed plants in each generation were related, often closely related, and that all were exposed to the same conditions, which, as we shall hereafter find, is a very important circumstance, it is not at all surprising that the difference between them should have somewhat decreased in the later generations." (p. 56.)

Further light was thrown upon these points by two kinds of subsidiary experiments. In one case, the cross was made between two flowers of the same plant of *Ipomœa*, while other flowers were self-fertilized as before. On raising seedlings from the two lots, it was found that such crossing gave no superiority: indeed, the offspring of the self-fertilized flowers appeared to be rather more vigorous than the close-crossed. And other experi-

ments led to the same conclusion, namely, that there was no particular benefit from cross-fertilization on the same plant. In the other case, the cross was made not only between the flowers of distinct plants, but between those from different sources, and which had presumably grown under somewhat different conditions. For instance, several flowers of the ninth generation of crossed plants of *Ipomœa* were crossed with pollen taken from the same variety, but from a distant garden. The resulting seedlings showed the benefit of the fresh stock remarkably, being as much superior in vigor to those of the tenth inter-crossed generation as the latter were to the self-fertilized plants of the corresponding generation. In height they were as 100 to 78, over the ordinary inter-crossed; and in fertility, as 100 to 51. Indeed, Mr. Darwin's main conclusion from all his observations is, "that the mere act of crossing by itself does no good. The good depends on the individuals which are crossed differing slightly in constitution, owing to their progenitors having been subjected during several generations to slightly different conditions, or to what we call in our ignorance spontaneous variation."

The greater constitutional vigor of the crossed plants of *Ipomœa* was manifested in other ways than their rate or amount of growth; they better endured exposure to a low temperature or sudden changes of temperature; they blossomed earlier; and they were more fertile. The difference in fertility varied greatly in degree (the extremes in different experiments and in different generations being 100 to 99 and 100 to 26), but was always sustained. Also, "the impaired fertility of the self-fertilized plants was shown in another way, namely, by their anthers being smaller than those in the flowers on the crossed plants. This was first observed in the seventh generation, but may have occurred earlier. . . . . The quantity of pollen contained in one of the self-fertilized was, as far as could be judged by the eye, about half of that contained in one from a crossed plant. The impaired fertility of the self-fertilized plants of the eighth generation was also shown in another manner, which may often be observed in hybrids—namely, by the first-formed flowers being sterile."

Similar experiments were made, but not carried to the same extent, upon fifty-seven other species of plants, belonging to fifty-two genera, and to thirty great natural families, the species being natives of various parts of the world. The results—the details and discussion of which occupy the bulk of this volume—vary greatly, some plants making a better, and others a less good showing for the advantage of cross-fertilizing, and this advantage manifesting itself in different ways, some in vigor or amount of growth, some in hardiness, most in fertility; but

with twelve cases in which the crossed plants show no marked advantage over the self-fertilized. There were, however, fifty-seven cases in which the crossed exceeded the self-fertilized by at least five per cent, generally by much more.

Increase of vigor, as evinced in growth, appears generally to be accompanied by increased fertility; but sometimes the good of crossing was manifested only in productiveness, i. e., in a larger amount of seed. This proved to be the case in *Eschscholtzia*, in which—strange to say—self-fertilized plants of several generations were superior in size and weight to inter-crossed plants, even when the crossing was between flowers derived on one side from American, on the other from English seed, from which, upon Mr. Darwin's view, the maximum benefit should be gained. This instance, however, stands alone. Yet it is approached by several others, in a manner which might have negatived the general conclusions of the research, if they had been hastily gathered from a small number of trials.

For example, in the sixth self-fertilized generation of *Ipomœa purpurea*, one of these plants took the lead of its competitor, kept it almost to the end, and was ultimately overtopped only by half an inch on a total height of several feet. To ascertain whether this exceptionally vigorous plant would transmit its power to its seedlings, several of its flowers were fertilized with their own pollen, and the seedlings thus raised were put into competition with ordinary self-fertilized and with inter-crossed plants of the corresponding generation. The six children of Hero (the name by which this individual was designated), beat the ordinary self fertilized competitors at the rate of 100 to 84, and the inter-crossed competitors at the rate of 100 to 95; and in the next generation the self-fertilized grand-children beat those from a cross between two of the children at the rate of 100 to 94. In the next generation the seedlings were raised in winter in a hot-house, became unhealthy, and the experiment terminated without marked result. Moreover the remarkable vigor of growth in Hero and its progeny was attended by somewhat increased fertility. Here, then, an idiosyncracy arose, from some utterly unknown cause,—a spontaneous variation of constitution, which was transmitted to posterity, and which gave all the benefit of cross-fertilization, and somewhat more, both as to vigor and fertility. A similar idiosyncracy made its appearance in the third generation of seedlings of *Mimulus luteus*.

Discordant or anomalous facts like these seem confusing, even though too few to affect seriously the grand result of the numerous experiments; but upon Darwinian principles, in which adaptations are ultimate results, they are to be expected, as a consequence of the general and apparently vague proclivity to vary.

In Foxglove,—the flowers of which are naturally self-sterile or nearly so, and in which crossing gave a marked advantage over self-fertilizing, both as to growth and productiveness,—a decided, though small advantage, appeared to come from the crossing of flowers on the same plant.

In *Origanum vulgare*, crosses were made between different plants of a large clump, long cultivated in a kitchen-garden, which had evidently spread from a single root by stolons, and which had become in a good degree sterile, as is usual under such conditions. The crossing caused rather more seed to form; but the seedlings from the crossed did not surpass in growth those of the self-fertilized; "a cross of this kind did no more good than crossing two flowers on the same plant of *Ipomœa* or *Mimulus*. Turned into the open ground, and both self- and cross-fertilized the following summer, and equal pairs of the resulting seeds planted on opposite sides of two very large pots, the crossed plants from seed showed a clear superiority over their self-fertilized brethren, at the rate of 100 to 86. But this excess of height by no means gives a fair idea of the vast superiority in vigor of the crossed over the self-fertilized plants. The crossed flowered first and produced thirty flower-stems, while the self-fertilized produced only fifteen, or half the number. The pots were then bedded out, and the roots probably came out of the holes at the bottom, and thus aided their growth. Early in the following summer, the superiority of the crossed plants, owing to their increase by stolons, over the self-fertilized plants, was truly wonderful. . . . Both the crossed and the self-fertilized plants being left freely exposed to the visits of bees, manifestly produced much more seed than their grandparents,—the plants of original clumps still growing close by in the same garden, and equally left to the action of bees."

These few cases must here suffice, and they give a fair general idea of the main results reached,—somewhat qualified, however, by certain instances in which little or no benefit was observed. Let it be remarked that while most of the cases show decided and unequivocal good from the crossing, none of them unequivocally tell to the contrary, as the advantage appears sometimes in one direction, sometimes in another. "Thus, the crossed and self-fertilized plants of *Ipomœa*, *Papaver*, *Reseda odorata*, and *Limnanthes* were almost equally fertile, yet the former exceeded considerably in height the self-fertilized plants. On the other hand the crossed and self-fertilized plants of *Mimulus* and *Primula* differed to an extreme degree in fertility, but by no means to a corresponding degree in height or vigor."

We must wholly omit — among many other things — the interesting account of self-sterile plants, meaning here

not those in which the pollen does not reach the stigma unaided, but those in which it is impotent, or nearly so, when applied, although efficient upon the stigma of another individual. *Verbascum*, *Passiflora*, *Corydalis*, and many Orchids afford instances of this sort. In these the advantage of cross-fertilization rises to a necessity. A noteworthy fact respecting them (of which Mr. Darwin makes much) is, that such self-sterility, or the reverse, is influenced by slight changes in the conditions, such as difference in temperature, grafting on another stock, and the like. In South Brazil, Fritz Müller found that for six generations all his plants of *Eschscholtzia Californica* were completely sterile, unless supplied with pollen from a distinct plant, when they were completely fertile. This was not the case in English plants, which, when covered by a net, set a considerable number of capsules, the seeds of which, by weight, were as 71 to 100 of those on plants intercrossed by bees. These Brazilian seeds, sent to England, yielded plants with moderately self-fertile flowers, and this limited self-fertility was increased in two generations of English growth. Conversely, seeds from English plants grown in Brazil were more self-fertile than those reared in Brazil for several generations; yet "one which did not flower the first year, and was thus exposed for two seasons to the climate of Brazil, proved quite self-sterile, like a Brazilian plant, showing how quickly the climate had acted on its sexual constitution." Having observed that certain individuals of Mignonette were self-sterile, Mr. Darwin secured several such plants under separate nets, and by inter-crossing these for a few generations, obtained plants which inherited this peculiarity, so that "without doubt a self-sterile race of Mignonette could easily have been established."

Nine of the twelve chapters are devoted strictly to the effects of cross and self-fertilization. The tenth considers the "means of fertilization." Cross-fertilization is favored or ensured by: 1, the separation of the sexes; 2, the maturity of the male and female sexual elements at different periods; 3, dimorphism or even trimorphism; 4, various mechanical contrivances; 5, the more or less complete inefficiency of a flower's own pollen on its stigma, and the prepotency of pollen from any other individual over that from the same plant. We understand that Mr. Darwin is just now occupied in revising and extending his various papers upon these topics, with a view to their publication in a volume. Here he gives a list of plants which, when insects are excluded, are either quite sterile or produce less than half the number of seeds yielded by unprotected plants. This is followed by a list of plants which, when protected from insects, are either quite fertile or yield more than half the number of seeds produced by unprotected plants.

"Each of these lists contains by a mere accident the same number of genera, viz., forty-nine. The genera in the first list include sixty-five species, and those in the second sixty species; the Orchideæ in both being excluded. If the genera in this latter order, as well as in the Asclepiadeæ and Apocynaceæ, had been included, the number of species which are sterile if insects are excluded would have been greatly increased; but the lists are confined to species which were actually experimented on. The results can be considered as only approximately accurate, for fertility is so variable a character, that each species ought to have been tried many times. The above number of species, namely, 125, is as nothing to the hosts of living plants; but the mere fact of more than half of them being sterile within the specified degree, when insects are excluded, is a striking one; for whenever pollen has to be carried from the anthers to the stigma in order to ensure full fertility, there is at least a good chance of cross-fertilization. I do not, however, believe that if all known plants were tried in the same manner, half would be found to be sterile within the specified limits; for many flowers were selected for experiment which presented some remarkable structure; and such flowers often require insect-aid." (p. 370.)

It is worth noticing that *Trifolium repens* and *T. pratense* (the common white and red clovers) have a place in the first list; *T. arvense* and *T. procumbens* in the second. Darwin refers to Mr. Miner's statement that "in the United States, hive-bees never suck the red clover," and says it is the same in England, except from the outside through holes bitten by humble-bees; yet that H. Müller has seen them visiting this plant in Germany, for the sake both of pollen and nectar, which latter they obtained by breaking apart the petals. Darwin has not qualified his statement, long ago made, of the complete sterility of red clover protected from insects; but Mr. Meehan asserts that protected plants are fertile in this country, without, however, giving details or the rate of fertility. In *T. arvense*, "the excessively small flowers are incessantly visited by hive and humble-bees; when insects were excluded the flower-heads seem to produce as many and as fine seeds as the exposed heads."

As to cross-fertilization, "the most important of all the means by which pollen is carried from the anthers to the stigma of the same flower, or from flower to flower, are insects, belonging to the orders of Hymenoptera, Lepidoptera, and Diptera; and in some parts of the world, birds." In a note the author cites all the cases known to him of birds fertilizing flowers. These are chiefly humming-birds. "In North America they are said to frequent the flowers of *Impatiens*" (for which Gould, Trochilidæ, is referred to as authority, and a reference is given to the Gardeners' Chronicle, which we find relates to something else in South

America); and this is all concerning the United States. Can it be that there are no references in print to the most familiar fact that our humming-bird is very fond of sucking the blossoms of Trumpet Creeper (*Tecoma radicans*) and of Honeysuckles? Both these are, in size and arrangement of parts, well adapted to be thus cross-fertilized.

Flowers are rendered conspicuous to birds and still more to insects, by bright colors. And as "almost every fruit which is devoured by birds presents a strong contrast in color with the green foliage, in order that it may be seen, and its seeds disseminated," so the proportionally large size and the bright colors of the corolla, or in some cases the equally bright hues of adjoining parts of the flower, or of the inflorescence, are correlated to visiting insects,—have come to pass, as Darwin would say, in consequence of the visits of insects, through the advantages in vigor and productiveness gained by cross-fertilization. He is ready to adopt even the idea of Conrad Sprengel, which seemed to be so fanciful, that marks and streaks on the corolla serve as guides to the nectary: for, although insects are well able to discover the nectar without the aid of guiding marks, yet they are of service by facilitating the search and enabling insects to suck a greater number of blossoms within a given time, which is tantamount to greater opportunity for cross-fertilization.

That odors attract insects is certain and many flowers are both conspicuous and odoriferous, while others make up in fragrance what they lack in show. "Nägeli affixed artificial flowers to branches, scenting some with essential oils, and leaving others unscented: and insects were attracted to the former in an unmistakable manner."

"Of all colors white is the prevailing one; and of white flowers a considerably larger proportion smell sweetly than of any other color, namely, 14·6 per cent; of red, only 8·2 per cent are odoriferous. The fact of a larger proportion of white flowers smelling sweetly may depend in part on those which are fertilized by moths requiring the double aid of conspicuousness in the dusk and of odor. So great is the economy of nature, that most flowers which are fertilized by crepuscular or nocturnal insects emit their odor chiefly or exclusively in the evening. Some flowers, however, which are highly odoriferous depend solely on this quality for their fertilization, such as the night-flowering stock (Hesperis) and some species of Daphne; and these present the rare case of flowers which are fertilized by insects being obscurely colored."

"The shape of the nectary and of the adjoining parts are likewise related to the particular kinds of insects which habitually visit the flowers; this has been well shown by H. Müller by his comparison of lowland species, which are chiefly visited by bees, with Alpine species belonging to the same genera, which are visited by butterflies."

"Pollen contains much nitrogen and phosphorus—the two most precious of all the elements for the growth of plants—but in the case of most open flowers, a large quantity of pollen is consumed by pollen-devouring insects, and a large quantity is destroyed during long-continued rain. With many plants this latter evil is guarded against, as far as is possible, by the anthers opening only during dry weather, by the position and form of some or all of the petals, by the presence of hairs, etc.; also, as Kerner has shown in his interesting essay, by the movements of the petals or of the whole flower during cold and wet weather. In order to compensate the loss of pollen in so many ways, the anthers produce a far larger amount than is necessary for the fertilization of the same flower. I know this from my own experiments on Ipomœa, given in the Introduction; and it is still more plainly shown by the astonishingly small quantity produced by cleistogene flowers, which lose none of their pollen, in comparison with that produced by the open flowers borne by the same plants; and yet this small quantity suffices for the fertilization of all their numerous seeds. Mr. Hassall took pains in estimating the number of pollen-grains produced by a flower of the Dandelion, and found the number to be 243,600, and in a Pæony 3,654,000 grains. The editor of the 'Botanical Register' counted the ovules in the flowers of *Wisteria sinensis*, and carefully estimated the number of pollen-grains, and he found that for each ovule there were 7,000 grains." (pp. 376, 377.)

These are probably fair averages of the numerical ratio of pollen to ovules in flowers which are adapted to be fertilized by insect agency. Their meaning in "the economy of nature" is seen by a comparison on the one hand with *anemophilous*, i. e., wind-fertilized, flowers, in most of which there is a vastly greater disproportion between the numbers—compensating for inevitable waste—and on the other with *cleistogenous* flowers, namely those small and less developed blossoms which some plants produce in addition to the ordinary sort, and which fertilize as it were in the bud, necessarily by their own pollen. Here is no waste, and accordingly the anthers are very small, and the pollen-grains not many times more than the ovules: also such flowers are never brightly colored, never odoriferous, and they never secrete nectar.

The only advantages of this close-fertilization which we can think of are sureness and strict likeness; both of which are quite as well secured by budding-reproduction. Now, as cleistogene flowers are borne, we believe, chiefly and perhaps only, by species whose normal blossoms are adapted for insect-fertilization, they must be regarded as a subsidiary arrangement, a safeguard against failure of proper insect-visitation. As the volume before us amply shows, this failure is in general provided for by a more or less wide margin of self-fertilization

in the very flowers which are adapted for crossing. In *Impatiens*, *Viola*, and the like, it is provided for by separate flowers, the special adaptations of which are unmistakable.

H. Müller appears to have shown "that large and conspicuous flowers are visited much more frequently and by many more kinds of insects than are small inconspicuous flowers. He further remarks that the flowers which are rarely visited must be capable of self-fertilization, otherwise they would quickly become extinct." Mr. Darwin's list seems to show that, as a rule, they are so; yet many very small flowers, like those of *Trifolium arvense*, and small and dingy ones, like those of *Asparagus*, are freely visited by bees; and, conversely, many large and conspicuous flowers which are frequented by insects are none the less self-fertilizable. Throughout we find that such things do not conform to arbitrary or fixed rules; and this favors the idea that the differences have been acquired. Mr. Darwin conjectures that the self-fertilizing capabilities of many small and inconspicuous flowers may be comparatively recent acquisitions, on the ground that, if they were not occasionally intercrossed, and did not profit by the process, all their flowers would have become cleistogenous, "as they would thus have been largely benefited by having to produce only a small quantity of safely protected pollen."

Mr. Darwin's experiments tending to prove that cross-fertilization between flowers on the same plant is of little or no use, he is naturally led to consider the means which favor or ensure their fertilization with pollen from a distinct plant. This must needs take place with dicœcious plants, and is likely to occur with the moncœcious, and is in some cases secured (as in Walnut and Hazelnut) by some trees being proterandrous and others proterogynous, so that they will reciprocally fertilize each other. In ordinary hermaphrodite species the expansion of only a few blossoms at a time greatly favors the intercrossing of distinct individuals, although, in the case of small flowers it is attended with the disadvantage of rendering the plants less conspicuous to insects. Our common Sundews furnish a good illustration of this. They abound wherever they occur, and are for a long while in blossom, but each plant or spike opens but one flower at a time. The fact of bees visiting the flowers of the same species as long as they can, instead of promiscuously feeding from the various blossoms nearest within reach, greatly favors such intercrossing. So does the remarkable number of flowers which bees are able to visit in a short time (of which mention will be made), and the fact that they are unable to perceive without entering a flower whether other bees have exhausted the nectar. Then dichogamy (the maturation of one sex in a hermaphrodite flower earlier than

the other) is so prevalent that it may almost be regarded as the rule; and this ensures such crossing between few-flowered plants, and greatly favors it in the case of spikes, racemes, and the like. For, proterandry being the commonest arrangement, so that the younger flowers act as male, and the older as female, and bees habitually alighting at the bottom and proceeding upward, they carry the pollen from the upper and younger flowers to stigmas of the lower and older flowers of the next spike, and so on. Heterogonism (see this Journal for December, p. 82), which is less common, operates precisely like complete dicœcious separation of the sexes in this respect, and with the advantage that all the individuals are seed-bearing. Most of the special arrangements peculiar to certain families, such as Orchids, or to plants—such as *Posoqueria*, with its wondrous mechanism for quickly stopping out access to the stigma when the pollen is violently discharged upon some insect, but opening the orifice the next day—are of a kind to favor the crossing of distinct plants. Prepotency of other pollen, which may accompany the other arrangements or exist independently, acts largely and powerfully toward the same end. Our author investigates this at some length: we cite for illustration a single but a strong case. The stigmas of a long-styled Cowslip were supplied with pollen from the same plant, and again, after twenty-four hours, with pollen of a short-styled, dark-red Polyanthus, a variety of the same species: from the resulting seeds twenty seedlings were raised, and all of them bore reddish flowers; so that the effect of the plant's own pollen, though placed on the stigmas twenty-four hours previously, was destroyed by that of the red variety. The same thing is shown by the impossibility in many cases of raising two varieties of the same species pure if they grow near each other. "No one who has had any experience would expect to obtain pure cabbage-seed, for instance, if a plant of another variety grew within 200 or 300 yards." And a veteran cultivator once had his whole stock of seeds seriously bastardized by some plants of purple Kale which flowered in a cottager's garden half a mile away. Mr. Gordon records a case of the crossing between Primroses and Cowslips through pollen carried by bees over more than two kilometers, or an English mile and a quarter.

We must copy the close of this section—long though it be—because of its capital illustration of the topic in hand, and for the teleological lesson which it teaches.

"The case of a great tree covered with innumerable hermaphrodite flowers, seems at first sight strongly opposed to the belief in the frequency of intercrosses between distinct individuals. The flowers which grow on the opposite sides of such a tree will have been exposed to somewhat different conditions, and a cross

between them may perhaps be in some degree beneficial; but it is not probable that it would be nearly so beneficial as a cross between flowers on distinct trees, as we may infer from the inefficiency of pollen taken from plants which have been propagated from the same stock, though growing on separate roots. The number of bees which frequent certain kinds of trees when in full flower is very great, and they may be seen flying from tree to tree more frequently than might have been expected. Nevertheless, if we consider how numerous are the flowers, for instance, on a Horse-chestnut or Lime-tree, an incomparably larger number of flowers must be fertilized by pollen brought from other flowers on the same tree, than from flowers on a distinct tree. But we should bear in mind that with the Horse-chestnut, for instance, only one or two of the several flowers on the same peduncle produce a seed; and that this seed is the product of only one out of several ovules within the same ovarium. Now we know from the experiments of Herbert and others that if one flower is fertilized with pollen which is more efficient than that applied to the other flowers on the same peduncle, the latter often drop off; and it is probable that this would occur with many of the self-fertilized flowers on a large tree, if other and adjoining flowers were cross-fertilized. Of the flowers annually produced by a great tree, it is almost certain that a large number would be self-fertilized; and if we assume that the tree produced only 500 flowers, and that this number of seeds were requisite to keep up the stock, so that at least one seedling should hereafter struggle to maturity, then a large proportion of the seedlings would necessarily be derived from self-fertilized seeds. But if the tree annually produced 50,000 flowers, of which the self-fertilized dropped off without yielding seeds, then the cross-fertilized flowers might yield seeds in sufficient number to keep up the stock, and most of the seedlings would be vigorous from being the product of a cross between distinct individuals. In this manner the production of a vast number of flowers, besides serving to entice numerous insects and to compensate for the accidental destruction of many flowers by spring-frosts or otherwise, would be a very great advantage to the species; and when we behold our orchard-trees covered with a white sheet of bloom in the spring, we should not falsely accuse Nature of wasteful expenditure, though comparatively little fruit is produced in the autumn."

The Horse-chestnut is not altogether a well-chosen example, for in it, as in our Buckeyes, a very large proportion of the flowers in the thyrsus are usually male, with barely a vestige of pistil. These serve, however, to increase the show, in the manner here illustrated, as well as to furnish abundance of pollen.

The section on anemophilous (wind-fertilized) plants,—their interest as survivals of the earlier phænogamic vegetation,—the speculation as to how, when flying insects came to prevail, an anemophilous plant may have been rendered entomophi-

lous,—how pollen, being a most nutritious substance, would soon have been discovered and devoured by insects, and by adhering to their bodies be carried from anthers to stigma and from one flower to another,—how a waste secretion, such as honey-dew or glandular exudations, may have been developed into nectar and utilized as a lure,—the interesting illustrations of the vast amount of pollen produced by anemophilous plants, and the great distances to which their light pollen is often carried by the wind,—all these inviting topics we must now pass by.

In passing we note the remark that "the excretion of a sweet liquid by glands seated outside of a flower is rarely utilized as a means of cross-fertilization by the aid of insects;" and the sole exception alluded to is that of the bracts of *Marcgraviaceæ*. But a parallel case is afforded by many species of *Euphorbia*, and notably in a striking species cultivated in conservatories, under the name of *Poinsettia*. Here the attraction to the eye is supplied by the intense red coloration of ordinary leaves placed next to the inflorescence, and that to the palate or tongue (if either term may be allowed), by a large cup-shaped gland on the side of the involucre, which contains or surrounds the naked and greatly simplified flowers of both sexes.

That anemophilous plants are prevailingly diclinous (either monœcious or dicœcious) is speculatively connected with their antiquity; that they are very largely trees or shrubs is because "the long life of a tree or bush permits of the separation of the sexes with much less risk of evil from impregnation occasionally failing, and seeds not being produced, than in the case of short-lived plants. Hence it probably is, as Lecoq has remarked, that annual plants are rarely dicœcious." The number of anemophilous species is comparatively small, but that of individuals of the species strikingly large, so that they form of themselves, in cold and temperate regions, where plant-fertilizing insects are fewer, either vast forests, as of Coniferæ, birches, beeches, etc., or meadows, and glades, as of grasses, sedges, and rushes. Being thus either necessarily or prevailingly cross-fertilizable and gregarious, it is not wonderful that they should hold their own unchanged in various parts of the world. Still their advantage is gained at the expense of the production of an enormous superfluity of pollen, a costly product; and, when dicœcious, half the individuals produce no seed. Hermaphroditism with dichogamy, or some equivalent, and transportation by an appeal to the senses and appetites of insects, secures all the advantages with least expenditure. The earliest fertilization in plants took place by the locomotion of the fertilizing or even of the fertilized material, in manner of most of the *Algæ:* mainly losing this as vegetation became terrestrial, the transpor-

tation was committed to the winds, and finally in the higher plants more economically consigned to insects.

The eleventh chapter, on the habits of insects in relation to the fertilization of flowers, is one of the interesting and readable, although the shortest. It appears that the prince of naturalists, Aristotle, had observed more than 2000 years ago that the hive-bee visited the flowers of the same species as long as possible before going to a different species. This holds true of all kinds of bees and certain other insects, generally, but not absolutely. Although, as Lubbock has recently proved, bees are much guided by color, yet they hold to the practice just mentioned in spite of difference in this respect, being botanists enough to know that color is not a good specific character. Mr. Darwin has repeatedly seen humble-bees flying straight from a red Fraxinella to a white variety, from one Larkspur to a different colored variety, and the same as to Primroses and Pansies. But two species of Poppy were by some bee treated as one; and H. Müller traced hive-bees from blue hyacinths to blue violets. On the other hand, Darwin's bees fly straight from clump to clump of a yellow Œnothera without turning an inch from their course to Eschscholtzias with yellow flowers which abound on either side. This constancy to species, however, is manifested only when their flowers abound; a fact which may have led Mr. Darwin to his explanation of the reason of it.

"The cause probably lies in insects being thus enabled to work quicker; they have just learnt how to stand in the best position on the flower, and how far and in what direction to insert their proboscides.* They act on the same principle as does an artificer who has to make half-a-dozen engines, and who saves time by making consecutively each wheel and part for all of them. Insects, or at least bees, seem much influenced by habit in all their manifold operations; and we shall presently see that this holds good in their felonious practice of biting holes through the corolla." (p. 420.)

As to this latter practice —

"The motive which impels bees to gnaw holes through the corolla seems to be the saving of time, for they lose much time in climbing into and out of large flowers, and in forcing their heads into closed ones. They were able to visit nearly twice as many flowers, as far as I could judge, of a *Stachys* and *Pentstemon* by alighting on the upper surface of the corolla and sucking through the cut holes, than by entering in the proper way. Nevertheless each bee before it has had much practice, must lose some time in making each new perforation, especially when the perforation has to be made through both calyx and corolla. This action therefore implies foresight, of which faculty we have abundant evidence in

* H. Müller had come to the same conclusion.

their building operations; and may we not further believe that some trace of their social instinct, that is, of working for the good of other members of the community, may here likewise play a part? Many years ago I was struck with the fact that humble-bees as a general rule perforate flowers only when these grow in large numbers near together," etc., etc. (p. 433.)

It appears that the cutting of these holes is done only by humble-bees, never by hive-bees. Yet the latter are quick to take advantage of them.

"In the early part of the summer of 1857 I was led to observe during some weeks several rows of the scarlet kidney-bean (*Phaseolus multiflorus*), whilst attending to the fertilization of this plant, and daily saw humble- and hive-bees sucking at the mouths of the flowers. But one day I found several humble-bees employed in cutting holes in flower after flower; and on the next day every single hive-bee, without exception, instead of alighting on the left wing-petal and sucking the flower in the proper manner, flew straight without the least hesitation to the calyx, and sucked through the holes which had been made only the day before by the humble-bees; and they continued this habit for many following days. Mr. Belt has communicated to me (July 28th, 1874) a similar case, with the sole difference that less than half of the flowers had been perforated by the humble-bees; nevertheless, all the hive-bees gave up sucking at the mouths of the flowers and visited exclusively the bitten ones. Now how did the hive-bees find out so quickly that holes had been made? Instinct seems to be out of the question, as the plant is an exotic. The holes cannot be seen by bees whilst standing on the wing-petals, where they had always previously alighted. From the ease with which bees were deceived when the petals of *Lobelia Erinus* were cut off, it was clear that in this case they were not guided to the nectar by its smell; and it may be doubted whether they were attracted to the holes in the flowers of the Phaseolus by the odor emitted from them. Did they perceive the holes by the sense of touch in their proboscides, whilst sucking the flowers in the proper manner, and then reason that it would save them time to alight on the outside of the flowers and use the holes? This seems almost too abstruse an act of reason for bees; and it is more probable that they saw the humble-bees at work, and understanding what they were about, imitated them and took advantage of the shorter path to the nectar. Even with animals high in the scale, such as monkeys, we should be surprised at hearing that all the individuals of one species within the space of twenty-four hours understood an act performed by a distinct species, and profited by it." (pp. 430, 431.)

But we must cut short our citations and remarks; passing by one of the most important points, relative to the amount of fertilizing work done by insects, namely, the evidence of the

extraordinary industry of bees and the number of flowers visited within a short time; which, as well as the distance to which pollen is sometimes transported, is far greater than one would have supposed. But the volume is reprinting by the Appletons, and will soon be within the reach of all,—along with a new edition of the orchid-fertilization book, the proper supplement to the present work, relating as it does to the class of plants in which the adaptation for fertilization by insects is carried to the highest degree of specialization and perfection.

ART. XVII.—*Note on Microdiscus speciosus;* by S. W. FORD.

IN my original description of this interesting Trilobite (this Journal, August, 1873) it is stated that the thorax is composed of four equal segments. The description, in so far as relates to this part of the animal organization, was drawn up from the study of a single specimen, showing the head, thorax and pygidium in nearly their natural positions, and apparently offering decisive testimony as to the true number of body-rings. Somewhat more than a year ago, however, I obtained from the Troy beds another specimen, of almost precisely the same dimensions, showing clearly but *three* segments in the thorax; and, subsequently, a much larger specimen showing the same number. This led me to re-examine, more critically, the specimen employed in the original description, when it was found that the head had slipped slightly forward, and that what I had regarded as the first pleura (all of the pleuræ of one side, as well as one-half of the head, being enveloped in the matrix) was a fragment of some foreign body that had fallen into the gap thus made. The deception, in the first instance, was rendered all the more complete from the fact that, by the displacement of the head alluded to, the articular fold of the first body-ring, which is ordinarily wholly hidden from view by the backward prolongation of the glabella, was exposed, thus making a very good case for a fourth segment. I now consider it certain that this species has never more than three body-rings. I have in my collection a small rolled-up specimen showing the extremities of but two body-segments, and I was at first led to think it possible that we had in this species an example of the metamorphoses of Trilobites, concerning which Barrande has taught us so much. But as I have observed since this specimen was obtained, an individual of even smaller size, with three perfectly formed body-segments, this notion is without foundation at the present time. I should here also add that the last body-

ring is not, as I originally believed it to be, firmly soldered to the pygidium.

It is a remarkable fact that, under each of the four trilobitic genera represented in the Troy Primordial, viz., *Olenellus*, *Conocoryphe*, *Microdiscus* and *Agnostus*, there should be found, in this fauna, a species affording an example of a well-marked departure from the usual structure of the genus to which it belongs. Thus *Microdiscus speciosus* has but three body-rings, as already stated, while all the other described species of the genus whose thorax is known have four; *Agnostus nobilis* has but one body-ring, while nearly all of the other species have two; *Conocoryphe trilineata*, with its singularly-cleft caudal margin stands widely apart from all the other certainly known species of the genus; while *Olenellus asaphoides*, unlike the other described species in which the thorax has been observed, has none of its anterior pleuræ extravagantly prolonged as compared with the others. In this respect this latter species, as Barrande has already indicated, sustains the same relation to the Vermont forms of the genus as do the Swedish *Paradoxides* to their Bohemian allies.

November 20th, 1876.

ART. XVIII.—*On Water Courses upon Long Island;* by ELIAS LEWIS, Jr.

IT has been estimated that of the forty-two inches of average annual rainfall upon Long Island more than three-fourths sinks directly into the porous soil. The excess which occurs when the fall is unusually heavy, or the surface frozen, makes its way into the innumerable valleys which traverse its surface. These valleys may therefore be considered as lines of surface drainage, the principal of which have their source on the high grounds near the center of the island, whence a portion of them extend northward toward Long Island Sound, others southward to the bay or ocean.

On the north side of the island, of which we shall first speak, many small lateral valleys open into the larger ones, cutting the surface into a series of valleys and hills, forming a landscape exceedingly beautiful and picturesque.

The high grounds referred to comprise a range of hills which extend more than sixty miles in a direction parallel with that of the island, and which vary from 150 to 384 feet in height. This range is called, absurdly enough, the backbone of the island. It consists, however, of glacial drift, with boulders, many of immense size, but is wholly without rock in place. It is upon this range, quite at the top in many instances, that the

principal water courses have their source. From these elevations they extend as broad deep valleys, well cultivated or wooded, rarely presenting evidence of recent erosion.

An inquiry is suggested, how and when were they formed? The surface waste of water from the present volume of rainfall seems wholly inadequate to produce them. Much of this percolates the soil after reaching the valleys, and in many instances the bottom of the valleys, which is usually of gravels and sand, is covered deeply by an accumulation of sedimentary matter because the flow of water through them has not been sufficient to maintain them at their original depth. In the great watercourse which opens at Glen Cove there occurs, three miles southward from its termination, a deposit of fine clay six feet or more in thickness, and thirty feet below accumulated sediment in the valley. The fact that such deposits occur in the old water courses suggests, we think, feeble energy of erosion, and points to a time when it was more active than now.

The formation and maintenance of a valley implies that the material which filled it, or which might have filled it, has been removed by a stream of sufficient volume to accomplish the work. A quantity of rainfall is conceivable which would erode and deepen the valleys in question, and that such occured at a former period is quite possible, but we insist that while some erosion must occur when water moves over the surface of the ground, that the great development of these valleys, especially at their source, and upon the highest grounds, is not explained by the present surface waste. The watershed of the island upon the hills is narrow; frequently a few rods, or feet separates the source of a valley extending northward from one running southward.

We are inclined to look to an agent other than rainfall for the development of the surface sculpture of Long Island. Excepting its lower beds which may consist of Tertiary or Cretaceous deposits, or of both, the island is a glacial moraine,—a mass of debris both unmodified, and in every stage and form of modification. The surface valleys were evidently watercourses for sub-glacial streams supplied by the ever wasting ice while it still lay upon the coast. From this cause a deep erosion of the highest grounds was possible, and the general contour of the surface determined. The direction and course of all the principal valleys indicate their common origin. So deeply marked and well defined are they that little change in their general aspect seems to have taken place since the disappearance of the ice sheet from the coast. If from the surface valleys we turn to the similar but vastly greater ones on the north side of the island which now constitute the series of magnificent harbors upon its coast, we find proof that they too had their

origin in glacial times. These harbors are eight in number, and although in glacial drift are as truly fiords as those along the rocky coast of Greenland. They extend into the island from three to six miles, they are from half a mile to a mile and a half broad and are in the deeper portions from ten to twenty-five feet deep. They were probably deeper when free from sediment. In a few instances where tidal currents are strong the water is from thirty to fifty feet deep. The land on either side of the fiords is from a few feet to as much as 200 feet above tide, and the valleys continue long distances inland beyond where the tides reach. Many lateral valleys open into these, evidently cut by glacial streams. It is extremely probable that these great fiords were, at an early stage of the formation of the island, water-courses opening to the ocean, and were maintained as such until filled by accumulating drift. This may have occurred while the ice sheet still lay over the region, and the streams were under or sub-glacial ones. When however the valleys were finally filled with drift at their terminus the waters were arrested, and thenceforth discharged eastward and westward through, what is now, Long Island Sound.

There is no evidence that the fiord valleys have changed in their general contour since the glaciers disappeared. The facts undoubtedly imply that the coast stood at a greater elevation than now, for the glacial-fed streams must have swept the fiord valleys to their bottom. But Prof. Dana has shown long since that the Glacial period was probably one of elevation of Northern lands.

There is reason for the conclusion, however, that some deepening of the principal surface valleys has taken place subsequently to the disappearance of the ice, which may be attributed to streams. There occurs in many instances fragmental deposits of sand and gravel along their banks, ten to twenty or more feet above the bottom, which seem to be remains of flood plains, and indicate erosion to that extent. If this be correct, a more abundant rainfall at a former period is suggested, and it may have occurred while the ice still lay upon New England. Chilled by its presence the vapor-laden air from the ocean might have dropped its moisture in more abundant rain or snow upon the coast, and local accumulation of snow upon the hills during winter may have aided in swelling the eroding streams.

The water-courses which open southward from the central hills of the island extend over a nearly uniform plain; they are of moderate depth, rarely greater than twenty feet, have few tributaries, and are quite direct and continuous from the hills to the bay. They are over a formation geologically different from that on the north side of the hills, it being stratified gravel and sand,

proving the presence of the ocean over the region subsequent to the deposit of the drift. The stratified beds occur at all heights up to 260 feet above tide, and imply a submergence of the coast to that extent. There still remained, however, many elevations above the ocean (or if they were submerged their contour was not altered), for they now show the same development of old valleys as we have noticed on the north side of the hills. This is important in explaining the newer valleys over the stratified, and newer beds. We have traced several of these to their source, and find that in each instance the new valley is a continuation of an old one. These new valleys are called locally "plain valleys," because they traverse the plains, and there are thirty of them between East New York and Riverhead, a distance of fifty miles.

It is easy to see why the new valleys are continuous with those upon the higher grounds, as the precipitation upon the region would flow into the old valleys, giving direction to the surface waste in streams. These at the period of submergence, which was probably the closing of the Glacial, or opening of the Champlain period, would continually empty into the bay or ocean near. As the coast arose from the water the shore line receded, but the streams would still reach it, and slowly but surely erode the plain valleys in question. It thus appears that the water courses over the modified drift of the plains have their origin in older valleys worn by glacial torrents in a preceding age.

There is a source of valley erosion on both sides of Long Island which has not yet been mentioned. It arises from springs fed from rainfall, which break out and flow during the whole, or part of the year in some of the valleys. These springs are from under-drainage. On the south side of the island they appear from one to three miles from the coast, forming streams of great beauty and purity. It is from this source that the city of Brooklyn is supplied with its wonderfully pure water. There is reason to conclude that the springs broke out farther inland at a former period. On the north side of the island springs appear in some of the valleys from which small streams flow a part of the year. In both instances, however, we should not expect the cropping out of springs, in valleys, until the valleys were formed. It is because, in most instances, the valleys have been cut down, to the level of saturation, that springs appear, and if at any period they cropped out farther inland in the valleys, or upon a higher level, it was because the level of saturation was higher than it now is. Any subsequent lowering of it has arisen from a diminished supply of water, consequent upon diminished precipitation.

In review the following conclusions seem to be sustained:—

1. The formation of the principal valleys about the hills of central Long Island and northward to the Sound was concurrent with the closing period of the ice over the region, but some deepening has taken place by water from rainfall, both from its surface waste, and from under-drainage, forming springs in some of the valleys.

2. The great fiord valleys were contemporaneous with the progress of the ice period.

3. The "plain valleys" have been formed by streams from both surface and under-drainage, and originated in older valleys which determined the flow of the eroding waters.

4. A further conclusion is suggested that the volume of precipitation over the region was greater at a former period than at the present time.

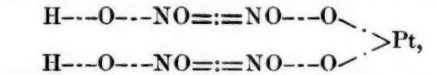
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

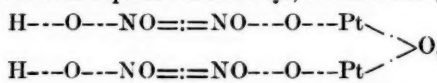
1. *On the Purification of Hydrogen gas.*—Although the use of hydrogen gas as a reducing agent in analytical operations has become quite general since it was proposed by Rose, yet no method of perfectly purifying this gas has been described. Schobig has made a series of experiments upon the use of a saturated solution of potassium permanganate for this purpose, the results of which appear to be quite satisfactory. The impurities which were introduced were the hydrogen compounds of sulphur, phosphorus, arsenic, antimony and carbon. The permanganate was used as neutral, acid, and alkaline solution, contained in a Bunsen wash-bottle. Careful examination of the gas after passing through a layer 10 cm. thick of the solution, either when only a single impurity was present or when all were mixed together, failed to show a trace of foreign substance. Hydrogen sulphide was found to be best removed by an alkaline solution; the other substances by a neutral or acid one. Even coal gas after passing slowly through a thickness of ten centimeters of the solution, deposited no carbon when passed through an ignited tube, the carbon being oxidized to carbon dioxide. As to the question whether hydrogen itself is not oxidized by the permanganate, the author made comparative experiments with neutral, acid and alkaline solutions, which showed that oxidation does take place, the maximum rate being about a third of a cubic centimeter per hour under the conditions employed, and this in the neutral solution. With the hydrogen thus perfectly purified the author succeeded in reducing a silver solution, in the dark and in the absence of organic matter. In dilute solutions the silver separated as a fine powder; in concentrated ones, it formed a mirror.—*J. pr. Ch.*, II, xiv, 289, Oct., 1876. G. F. B.

2. *On Hypovanadic Oxide and its Compounds.*—Crow has examined, under Roscoe's direction, the modes of production and the properties of the hypovanadic oxide of Berzelius (vanadium tetroxide) and some of its compounds, the vanadium being determined analytically either by titrition with permanganate or by fusing and weighing as pentoxide. Hypovanadic oxide, prepared by heating the chloride to redness in an atmosphere of carbon dioxide, is nearly pure, containing about 95 per cent of V_2O_4. It is a dark-green amorphous powder, insoluble in water, soluble in acids or alkalies, and absorbs oxygen from the air. The hydrate, obtained by precipitating a solution of the sulphate or chloride with sodium carbonate, filtering in an atmosphere of carbon dioxide and drying in a vacuum, is a black amorphous mass, having the composition V_2O_4, $(H_2O)_7$. Two trisulphates are described, one with seven, the other with four molecules of water, both of which are light blue deliquescent crystalline powders. Two similar disulphates were also obtained. The chloride, $V_2O_4Cl_2$, $(H_2O)_5$, prepared by dissolving the pentoxide in hydrochloric acid, reducing the solution with hydrogen sulphide, and evaporating, is a brown amorphous deliquescent mass, which yields a blue solution. Potassium hypovanadate, $K_2O.(V_2O_4)_2$, $(H_2O)_7$, is deposited in reddish-brown crystalline scales or needle-shaped crystals, when the sulphate or chloride is treated with excess of potassium hydrate and allowed to stand, closely stoppered, some hours. The sodium salt is similar. The ammonium, barium, lead and silver salts, the last two of which are anhydrous, are also described as brown or black precipitates.—*J. Chem. Soc.*, xxx, 453, Nov., 1876. G. F. B.

3. *On Plato- and Diplato-nitrites.*—Nilson has examined at length the peculiar double nitrites of platinous oxide and potassium, sodium, ammonium, silver, mercury and barium described by Lang, and, adopting Blomstrand's view that they are paired compounds of quinquivalent nitrogen, he considers them to contain the bivalent radical platotetranitrosyl, the acid from it,



being called platotetranitrosylic acid or platonitrosylic acid, and the salts platonitrites. He describes also new compounds containing another similar radical, in which, to the four nitrosyl groups, there are two platinum atoms and one more atom of oxygen. This radical he calls diplatotetranitrosyl, the free acid,



being diplatonitrosylic acid and the salts diplatonitrites. Nilson has prepared the potassium, rubidium, cæsium, ammonium, thallium, sodium, lithium, silver, calcium, strontium, barium, lead, magnesium, manganous, cobaltous, nickelous, ferrous, cupric, zinc,

cadmium, mercurous, aluminum, yttrium, erbium, cerium, lanthanum and didymium platonitrites, and silver, glucinum, aluminum, chromous, indium and ferric diplatonitrites. The former salts are for the most part beautifully crystallized, though the solution must be concentrated, since they are very soluble in water. The diplatonitrites, with the exception of the silver salt, which is green, are characterized by their brilliant red color.—*Ber. Berl. Chem. Ges.*, ix, 1722, Dec. 1876. G. F. B.

4. *On the behavior of Palladium in the Alcohol flame.*—Wöhler, as early as 1824, having observed that palladium, either in the form of foil or sponge, when heated in an alcohol flame covered itself with a thick layer of carbon, rendering the metal porous and brittle, and having, upon Graham's discovery of the remarkable occlusion of hydrogen by this metal, assumed this as the cause of the phenomenon observed by him, has now sought to verify the supposition by passing pure dry ethylene gas over palladium sponge, first at 100°, then at higher temperatures; but no result was obtained until a red heat was reached, when carbon was deposited and hydrogen evolved; the temperature being below that, however, at which ethylene itself decomposes. Since palladium has no affinity for carbon, the author suggests that the result observed may be due to an alternate union with hydrogen and separation therefrom. He also describes a convenient apparatus for showing the absorption of hydrogen by palladium and its evolution on heating.—*Ber. Berl. Chem. Ges.*, ix, 1713, Dec. 1876. G. F. B.

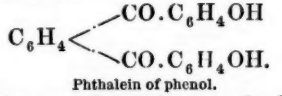
5. *On two new Dichlornaphthalenes.*—The α and β varieties of dichlornaphthalene, described by Faust and Saame, have fusing points of 35–36° and of 68° respectively; the γ variety, obtained by Atterberg, fuses at 107°. Cleve has prepared two new forms of this substance, δ-dichlornaphthalene, fusing at 114°, and ε-dichlornaphthalene, fusing at 135°, by the action of phosphoric chloride upon the calcium salts of the two napthalene-disulphonic acids described by Ebert and Merz. The former body is easily soluble in boiling alcohol, from which it crystallizes in broad brilliant plates. The latter is much less soluble and crystallizes in brilliant prisms.—*Bull. Soc. Ch.*, II, xxvi, 244, Oct. 1876. G. F. B.

6. *Emodin from the bark of Rhamnus frangula.*—Liebermann and Waldstein have examined the crystallized substance contained in the bark of *Rhamnus frangula* (buckthorn) with a view to ascertain the relation of the frangulinic acid of Faust, which he had recognized as an anthracene derivative, to the other isomers of alizarin. The crude material was obtained from Merck, and was prepared by extracting the bark with dilute soda solution, precipitating with hydrochloric acid, and after repeating this process, recrystallizing from alcohol. It was a red crystalline powder containing small quantities of some glucoside. Purified by recrystallization from glacial acetic acid, it gave beautiful orange silky needles, which after sublimation and crystallization

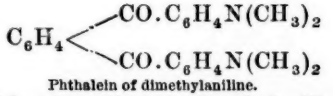
from absolute alcohol gave on analysis the formula $C_{15}H_{10}O_5$, which is that also of emodin, obtained from rhubarb root, as Liebermann had shown. The acetyl-derivative was prepared, and found to be acetyl-emodin. The hydrocarbon obtained by distilling it with zinc dust, was a mixture of anthracene with methyl-anthracene, as its oxidation products showed. A close comparison proved the substance to be identical with emodin. The bark contains only about 0·2 per cent of it. Whether frangulinic acid also actually exists in the bark, the authors promise further investigation to determine.—*Ber. Berl. Chem. Ges.*, ix, 1775, Dec. 1876.

G. F. B.

7. *On the Phthaleins of tertiary aromatic Bases.*—The remarkable analogy between dimethylaniline and phenol, shown in the production by Michler of a new body from the former by a reaction similar to the synthesis by Kolbe of salicylic acid from the latter, has led Fischer to follow up this analogy and to produce a phthalein of dimethylaniline corresponding exactly with the phthalein of phenol, one of Baeyer's remarkable bodies. This resemblance is clearly shown in the following formulas of these substances:



Phthalein of phenol.



Phthalein of dimethylaniline.

The new phthalein was obtained by the action of dimethylaniline upon phthalic chloride. The mixture heats, foams violently, and becomes dark-green in color. Water is added, the excess of dimethylaniline is removed by evaporation, and there is left a resinous mass which, crystallized from chloroform, gives greenish-yellow needles. It forms mono- and di-chlorides, chloro-platinates and picrates, the former of which are green, the latter yellow. Reduced with zinc dust, it gives a colorless base, like the phthaleins of the phenols.—*Ber. Berl. Chem. Ges.*, ix, 1753, Dec. 1876.

G. F. B.

8. *Standard Meter.*—M. G. Matthey presented to the French Academy at their meeting of Dec. 4th the platinum-iridium 4-meter bar, constructed for the International Geodetic Association. The metals were prepared by MM. Sainte-Claire Deville and Debray, and each time 450 ounces of platinum and 55 (50?) ounces of iridium were used. Five ingots thus prepared were cut in small pieces by a hydraulic press. The fragments were then melted in the same furnace and kept in a liquid state for a long time by a flame of oxygen and burning gas. The new ingot was forged and then rolled. The faces of the hammer and anvil were of polished steel constantly rubbed. The sheets after being well scraped were again melted in a rectangular furnace and produced a very homogeneous mass free from cracks or roughness on the bottom, sides or top. After the first forging a bar was obtained 35 cms. long, 7·5 cms. wide and 2·5 cms. thick, which weighed 15·105 kgs. and had a specific gravity of 21·522. A third of the

bar was cut off and the other two-thirds when forged and well annealed had the following dimensions: Length, 95 cms.; breadth, 2·5 cms.; thickness, 2 cms. Its weight was then 10·315 kgs. and its specific gravity, 21·648. The bar was next rolled between polished cylinders and brought to very nearly the required dimensions, of length 410 cms., breadth 2·1 cms., and thickness ·5 cms. Finally, a perfectly rectangular form was given to the bar by drawing it several times through a hole in a plate of steel. Each time the bar was heated to the highest temperature by a very large gas blowpipe fed with oxygen, and it was passed through the same hole until a force was no longer required to draw it through and it no longer underwent a sensible elongation. Each time when hammered, rolled or drawn, the metal, heated either in a great muffle or by the blowpipe, was cleaned by melted borax and by concentrated chlorhydric acid. The rule ought to receive from the makers, MM. Brünner, the high degree of polish of which it is susceptible, and which in its present rough condition it does not possess.

M. Deville in commenting on this communication gave the following result of an analysis of a portion of this alloy: Platinum, 89·42; iridium, 10·22; rhodium, ·16; ruthenium, ·10; iron, ·06; total, 99·96. The density computed from that of these components was 21·515; that observed, 21·516. A second analysis gave by computation 21·51; by observation, 21·508. He then exhibited two tubes of the same alloy made from the portion cut off from the bar as described above. These tubes are closed by spherical cups, of which one terminates in a capillary tube which enables the interior to be put in communication with Regnault's manometer. Each of these tubes is more than a meter long and one of them has a capacity of over a liter. This is to serve as an air thermometer for the determination of the boiling points of various liquids under known pressures. These tubes will have on their surfaces two lines a meter apart. The deviation compared with that of the second tube which will be kept in ice, will enable the exact temperature to be calculated. This will carry out a suggestion long since made by Regnault, and which has been applied to the measurement of high temperatures. It will be interesting to apply this method to the measurement of the lowest temperatures so far attained. These researches have an important bearing on metrology. All substances capable of being tempered, as glass and steel, undergo a change with time. Others which like zinc crystallize with changes of temperature also change with time. Hyaline quartz, according to Mr. Wild, appears exempt from this change. Does the platinum-iridium act like steel, zinc or quartz? This question will be solved by weighing the quantity of water which one of these tubes will contain at 0°. After all the experiments in which the temperature will be varied between very wide limits the capacity of the tube will be again measured. Each change of three milligrams in the weight of the meter will represent the volume of the tube corresponding to a change of one-

thousandths of a millimeter in the distance between the two lines marked on the tube.—*Comptes Rendus*, lxxxiii, 1090. E. C. P.

9. *Films of Water.*—Mr. TYLOR read a paper before the London Physical Society on the cohesion and capillary action of films of water under various conditions. The author endeavors to eliminate the action of all forces except that of gravity by immersing his "valves" in water. The models which he exhibited consisted of glass tubes about three inches in diameter and six inches high, filled with water and containing each a piston, which, on being raised, was capable of lifting by cohesion a heavy mass of metal, the nature of the surfaces in contact differing in the several instruments. From experiments with them he concludes that the time during which a heavy valve can be supported depends upon the size of the surface of contact, the difference of pressure within and without the moving parts, and the smoothness of the valve. On the contrary, dry bodies, such as Whitworth's surface planes, will adhere for an indefinite period. Mr. Tylor considers that the supporting of a body in water is due to a difference of pressure in the water itself, and he adduced Giffard's injector as showing that such differences can take place. He has also studied the form of a drop of water at a tap, and considers that when a fly walks on a ceiling its weight acts in the same manner as the heavy valves in the models exhibited.—*Nature*, xv, 131. E. C. P.

10. *Fog-Signals.*—Prof. HENRY at the recent meeting of the United States National Academy communicated some additional facts obtained in his long-continued and elaborate researches concerning sound in relation to fog-signals. His principal investigation this year had reference to the divergence of sound, especially as to the phenomenon known as the Ocean Echo. To test the explanation given by Prof. Tyndall, requiring reflection from the air, the trumpet of a siren was turned directly to the zenith. The blast was exceedingly intense, but no echo was heard from the prolongation of the axis of the trumpet, i. e., from the zenith. A loud echo was, however, heard from the whole circumference of the horizon, half of which was on land, the other half on water. This was repeated many times, and always with the same result. In one case a small cloud passed directly across the zenith, from which a few drops of rain fell into the mouth of the trumpet; still no sound was heard from the zenith, although sound continued to be heard from around the horizon. In this case on account of the divergence of the sound, portions of waves in every direction must have descended to the horizon, and as some of these must have reached the plane of the ocean in a path curving inward toward the source of sound, they would, when they reached the ear of the observer in the vicinity of the source, seem as if coming from a point in the horizon, and hence would give rise to the phenomenon of the ocean echo. Rays of sound at different distances from the ear could be reflected from the surface of the ocean and thus give rise to a prolonged echo. This is in

accordance with the fact observed during last summer, that a blast of five seconds' duration gave an echo that was prolonged twenty seconds. This could only be produced by ordinary reflection from a series of surfaces placed at different distances, an arrangement of the material of the atmosphere which (on the doctrine of probabilities) would not be of frequent occurrence.—*Nature*, xv, 129. E. C. P.

11. *The Siphon Recorder and Automatic Curb Sender.*—An illustrated article showing the practical as well as the theoretical construction of these instruments appears in *Nature* for Nov. 30th, 1876 (xv, 101). For some time after the introduction of submarine telegraphy the mirror galvanometer was the only instrument delicate enough to receive the messages transmitted through a long cable. The clerks must here read the message by watching the deviations of a spot of light from side to side. The siphon-recorder serves to draw a sinuous line by which the message is recorded in permanent form. The speed of sending will be greatly increased by sending after each current a second in the opposite direction. This is effected by the curb-sender. Three rows of holes are punched in a long strip of paper, the central row serving to carry the paper through the machine and the row on one side corresponding to the dots or positive currents, that on the other to the lines, or negative currents. When the paper passes through the machine it receives by clock-work a uniform motion. Two prickers are placed so as to correspond to the two outer rows of holes. When a hole passes, the corresponding pricker falls into it, and in so doing lifts a spring through an opening in the rim of a revolving wheel. The spring being caught in the rim of the wheel is obliged to remain there until the wheel makes one complete revolution and the opening in the rim returns to free it. The wheel makes one revolution while one space passes the pricker. When the spring is lifted into the rim of the wheel it makes connection between the battery and another set of springs, by which a current is sent through the cable, and shortly after it a second current is sent in the opposite direction. The currents are reversed when the other pricker acts. E. C. P.

II. Geology and Mineralogy.

1. *Report on the Transportation route along the Wisconsin and Fox Rivers in the State of Wisconsin, between the Mississippi River and Lake Michigan;* by Gouverneur K. Warren, Major of Engineers and Brevet Major General, U. S. Army. 114 pp. 8vo, with many maps. Senate Ex. Document, No. 28, 44th Congress. Washington, 1876.—General Warren's Report gives, first, a history of geographical knowledge and surveys respecting this old transportation route, then an account of the work that has been done by him or under his direction. We take the following facts from it.

The two streams—the Fox River which joins Lake Michigan at

the head of Green Bay, and the Wisconsin, which empties into the Mississippi at Prairie du Chien, come within a mile and a half of one another, at bends in each, near Portage City, where a granite ridge lies near the surface. The summit of this Portage region is about 218 feet above Lake Michigan, and 188 above the Mississippi, and the summit of this water level 208½ and 178½ feet. The stream from Portage eastward (Fox River) passes through Lake Winnebago (besides three smaller lakes), with a descent of 39 feet, and then plunges down the remaining 169½ feet along a limestone gorge whose sides are fifty feet or less in height.

The region of Lake Winnebago is bordered on the west by a low alluvial plain, partly marshy, which is represented on a map as reaching thirty miles west, and then extending in broad areas both north along Wolf River, and southwest along the Upper Fox toward Portage, and hence as including the other small lakes of the route. General Warren explains the origin of these features on the view that the whole alluvial area was originally a lake; at which time the waters drained off over the low granite ridge at Portage through the Wisconsin River to the Mississippi.

The height of this divide now existing at Portage is only a few feet, so that the westward flow would have necessarily taken place were the waters at the height required to make the lake. Afterward there was a subsidence to the northeastward which determined the flow in that direction (where the loose material easily gave way, while granite resisted wear in the opposite course) down the limestone slope, toward Green Bay, making thus the Lower Fox River channel. That this subsidence occurred after the Glacial period is stated to be shown by the absence of glacial drift from the alluvial plain.

The facts are of the highest interest because they tend to prove that the subsidence of the Champlain period (that following the Glacial), so well sustained for the eastern part of the Continent, in its higher latitudes, by facts along the coast of New England, Labrador, and regions farther north, and also on the shores of Lake Champlain and the St. Lawrence, actually affected also the interior of the Continent, for which it is so difficult to find evidences of change of level.

General Warren obtained the same proofs of a northward sinking, for the Champlain period, in the region between the Upper Mississippi and Lake Winnipeg. (See his Memoir on the Valley of the Minnesota.) He showed, by the facts, that Lake Winnipeg had once had a very great expansion and then had discharged southward by Minnesota River valley; but that afterward, subsequent to the Glacial period, a change of level in the land had taken place by a subsidence to the northward, or a subsidence that was relatively greatest in that direction, which turned their course into the present outlet toward Hudson's Bay.

In addition, General Warren observed that the southward discharge of Lake Winnipeg must have been determined by a previ-

ous rising of the land to the north (as referred to in a notice of his report in this Journal, vol. ix, p. 313); thus sustaining the idea of an elevation of the interior of the Continent at the opening of the Glacial period, and an elevation which was greatest to the north. These conclusions—an elevation increasing in amount northward, followed after the Glacial period by a subsidence increasing northward—were reached without reference to any preconceived hypothesis.

Sand-bars.—Gen. Warren also describes with detail the form and structure of the sand-bars in the Wisconsin River, giving facts that are of general geological interest. The surface of these bars has a gradual pitch up stream, and a steep front down stream—as in a ripple mark. The sands are dropped where there is still water along the shores, but the larger part in the still water on the down-stream edge of the bars, thus building up this edge toward the water's surface. The sand, where the current is strong, "is moved along the gentle slope of the upper side till the crest is reached, when it falls over and stops in the still water below." The bar thus grows and becomes more convex in its down-stream outline. Such sand-bars have a channel of deep water either side, and also tend to make, by acting as a dam at the low-water stage of the stream, large areas of deep still water above them. The changes in the current produced by the growth of the bars and the greater changes from change of level in the river by floods, produces frequent changes in the bars, so that they are not the same in position from year to year. At very low water, the bars may be mostly dry, with winding narrow channels of water among them. This tends to improve the navigation for the time; but a rise, if small and temporary, sends the water across these channels and fills them up.

The sand-bars made in the Mississippi by the discharge of the Wisconsin are of great extent. Besides pushing the deep water channel to the west shore, they act as a dam and make an area of relatively still water above, thus causing good navigation above the junction and bad below—a common fact at junctions in the rivers of the Mississippi basin. The Wisconsin River flows from a region of much less summer rain than the Mississippi, and is often at low-water stage when the latter is high; and hence it is made very shoal by sand-bars formed in its mouth.

The sands of the Wisconsin River bars are almost purely siliceous, and come from the drift deposits bordering its course. The specific gravity, "excluding voids," of two specimens from different parts was 2·6392 and 2·6667. For comparison the specific gravity of other sands was obtained, as follows: at St. Paul, Minnesota, on the Mississippi, 2·6397; at Rock Island, Illinois, 2·6166; at Saybrook Bar, mouth of Connecticut River, 2·6406; at Block Island, R. I., 2·6392; at Newport, R. I., 2·6563. The Report also compares different sands as to proportional fineness, giving the proportion that passed through sieves of different grades; and, also, as to the changes in volume in different sands

due to wetting when loose and packed. The loose sands of the Wisconsin River shrink in volume ·0146, and ·0197 (two specimens); while that of Saint Paul shrinks ·0695; that of Block Island, R. I., ·0788, and that of Newport, R. I., ·1352. These investigations of different sands were made in order to ascertain the reason why the Wisconsin sands are "easily moved"

2. *Ice work now going on in Newfoundland.*—Mr. S. MILNE gives many valuable facts on modern ice-work in Newfoundland in a paper in the Geological Magazine for September last, from which the following are here cited.

Ice forms on the shores from the spray and occasional snows, enveloping and thus grasping firmly the stones and bowlders beneath, and attaining considerable thickness; and when a northern pack strikes it, it is pushed up shore, sometimes to a distance of a hundred yards. In the movement the rocky surfaces beneath are polished and scratched in a style precisely like the work of glaciers. The breaking away of the pack near the water line leaves the stranded ice with a thick front called by the fishermen a *balacada*, a corruption probably of *baracada* of the Spanish. This shore ice, with its cargo of bowlders, stones and gravel, is often drifted off as the tide rises, and especially when a land breeze favors; and great lines of bowlders off the shore are thus made. In the same way the cables and anchors left on the shore have sometimes been carried off,—to the regret of the fishermen.

The blows made by the coast-ice when driven up the land, or by the floating ice when pushed ashore, have immense power and do great execution on the rocky bluffs. Scoresby's calculation, that the blow produced by one of the immense ice-fields is equal to that of 10,000,000,000 tons, affords an idea of the force of the impact in many cases, and aids us in realizing the greatness of the work of coast degradation carried on in every cold season by the reiterated strokes.

3. *The Glaciation of the Shetland Isles.*—In the Geological Magazine for May and June, 1870, my colleague, Dr. Croll, first pointed out that the Scotch and Scandinavian ice-sheets probably united on the floor of the North Sea, and thence moved westward toward the Atlantic. He was led to this conclusion by a consideration of the peculiar direction of the striæ in Caithness, in Shetland, and the Faroe Isles, as well as by the occurrence of marine shells in the bowlder clay of the northern parts of Caithness. He showed that the enormous *mer de glace* which pressed out on all sides from Scandinavia forced its way close to the Scotch coast-line, and in virtue of its greater size produced a slight deflection of the Scotch ice, causing it to over-ride portions of the main land. He stated that in all likelihood both the Shetland and the Faroe Isles were over-topped by the Scandinavian ice in its onward march toward the Atlantic.

During a recent traverse in Shetland I obtained evidence which tends to strengthen this remarkable theory. In the north island of Unst, the direction of the striæ, the bowlders on the surface,

and the stones in the till, clearly indicate that this island was glaciated by a mass of ice moving from east to west. The proofs of continental glaciation, which are comparatively clear in the north, are obscured in a great measure in the main island by the effects of a local ice-sheet. The nature of the bowlder clay, as well as the trend of the striæ in various localities, show that the movement of this local sheet was influenced by the general features of the country. In addition to these markings, however, others were found which could not have been produced by ice shedding off the land in the ordinary way. These cross the island, regardless of its physical features, and are often at right angles to the newer set. Lastly, the wide distribution of morainic matter with groups of moraines indicate the gradual disappearance of the local ice-sheet and the presence of small glaciers, where the ground presented favorable conditions for their development.

The islands are dotted over with small lochs; the most of these lie in peat or drift, while others occupy true rock basins. The singular absence of marine terraces ought not to escape notice, as bearing on the recent geological history of these islands, since the voes or sea-lochs are admirably adapted for their preservation.

These observations will be described in detail in a forthcoming paper before the Geological Society. JOHN HORNE.
—*Nature*, Dec. 14, 1876.

4. *Note on the relations of Balanus Estrellanus of the California Miocene;* by T. A. CONRAD. (From a letter to J. D. Dana, dated Philadelphia, Dec. 4, 1876.)—Some time ago I wrote you for your opinion of the propriety of classing *Balanus Estrellanus* (*Tamiosoma gregaria*) with the *Rudistæ*. It seemed so strange to me, that a member of the *Rudistæ* should be in Miocene strata, that I have recently studied its characters anew, and find it to be a true *Balanus*, and I think you will agree with me, if you consult the figure and description of *B. lævis* figured in Darwin's Monograph, pl. 4, fig. 2. In that figure the basis exhibits septa of the precise character of *B. Estrellanus;* besides, the loss of the basis shows the same structure as other Balani, but the opercular valves are not preserved. Mr. Gabb fully agrees with my determination.

I have also had occasion to restrict the number of genera which were supposed to be common to Cretaceous and Eocene strata. Thus I eliminate the genus *Cucullæa* from the Cretaceous fauna, it being represented by *Idonearca*. I think also that *Trigonia* died out at the close of the Cretaceous; for, of the many species known, none had ribs radiating from the beak, like a *Cardium*, and being unknown in Eocene strata; when the allied genus appears in the Miocene and recent fauna it assumes the radiated structure. I also exclude from the Cretaceous fossils the following genera of Veneridæ: *Callista*, *Caryatus*, *Dione*, *Grateloupea*, *Cryptogramma*, *Circe*, *Dosenia*, *Mercenaria*, *Venus*, etc., retaining only *Aphrodina*, *Cyclothyris*, *Baroda*, and *Dosiniopsis*. Some genera, as *Cardium*, *Pecten*, *Radula*, *Ostrea*, *Anomia*, *Spondylus*, *Axinæa*, *Turritella*, etc., were continued from Cretaceous strata to

the recent period, but I have not yet made out a list of all the extinct genera. As it is interesting to note the occurrence of corresponding extinct genera in America and India of the same Cretaceous horizon, I would remark that in Stoliczka's Paleontology of Southern India, figs. 1 to 5, pl. vi, represent the genus *Cyclothyris*, though referred to *Cyclameria* by Stoliczka; and figs. 17–19 (*Cytheria* Stol.) belong to *Aphrodina* Con. Both of these genera are common in North Carolina.

5. *Stromatopora.*—In the number of the Annals and Magazine of Natural History for January, *Stromatopora concentrica* is pronounced a Sponge in a paper on a new genus of Cretaceous Hexactinellid Sponges, by W. J. Sollas. A second paper, by H. J. Carter, treats of the close relationship of *Hydractinia*, *Parkeria*, and *Stromatopora*, thus making the genus, or part of it, Hydroid in its relations, and so removing it far from the Protozoans.

6. *Geological Survey of Victoria. Report of Progress*, by R. Brough Smyth.—The most important Report in this volume is a long one on the Devonian rocks of North Gippsland, by A. W. Howitt.

7. *Fossil Elephant in Washington Territory;* by Wm. O. Matzger. (From a letter dated Daytown, Washington Territory, July 8, 1876.)—The bones include a pelvis, jaw bone, tusk, and others. The pelvis measures 5 feet 10 inches across its widest part, and the tusk is 10 feet long. The jaw bone is two feet wide, and has one tooth on a side, measuring at top ten inches by three. The discoverer thinks that he has found portions of at least five individuals.

8. *Mesozoic Fossils*, Vol. I; Geological Survey of Canada. Part I. *On some Invertebrates from the coal-bearing rocks of the Queen Charlotte Islands*, collected by J. Richardson in 1872; by J. F. Whiteaves. 92 pp. 8vo, with 10 plates of fossils, and a map.—The Queen Charlotte Islands lie just to the north of Vancouver Island. The fossils are in general too imperfect for satisfactory identification. They include a large proportion of species of the Ammonite family. They have some Oölitic affinities, while "at least one or two are known to be Cretaceous," and indicate a relation in the beds rather to the Shasta Group (Lower Cretaceous) of California and of British Columbia, than to the Cretaceous of Vancouver, or the Chico group of California. No Vancouver species is found among them. They may belong just below the Cretaceous. Out of the 42 species of Mollusks, three—*Ammonites Brewerii*, *A. Stoliczkanus* and *Aucella Piochii*, are well-known California Cretaceous fossils.

9. *Miocene in Southern New Guinea.*—Mr. C. S. Wilkinson, of the Geological Survey of New South Wales, after an examination of specimens obtained in New Guinea by William MacLeay, Esq., announces the occurrence of Calcareous clays and other beds from Hall's Sound, which are of the *Lower Miocene*,—a fact of much interest since no marine Tertiary beds have yet been reported from Eastern Australia, while they are found in Victoria

and South Australia. Professor M'Coy, as Mr. Wilkinson states, has shown that the Miocene fossils of Southern Australia were closely related generically, and even specifically to those of many parts of Europe and America. The New Guinea species are mostly identical with those of Victoria. They include *Voluta anti-cingulata*, species of *Ostrea*, *Cytherœa*, *Crarsatella*, *Pecten*, *Turritella*, *Astarte*, *Corbula*, *Leda*, *Venus*, *Cypræa*, and other genera. Mr. Wilkinson makes the following concluding observations:

The discovery of these Miocene beds on the southern coast of New Guinea is one of considerable importance. Their occurrence, I believe, suggests the former land-connection of New Guinea with the Australian continent, and this belief is further borne out by the fact of the shallowness of the intervening sea.

From geological data it is believed that this continent [Australia] has not been submerged to any great extent, since the Lower Pliocene period; and we know that it has risen a little since the Upper Pliocene epoch, at least in Victoria, for the lava flows of that age, now forming the Werribee Plains, were *submarine* flows. And Mr. Daintree, formerly government geologist of Queensland, shows, in his pamphlet on the Geology of Queensland, that little upheaval of this portion of Australia has taken place since the volcanic outbursts of a late Tertiary epoch. Now, it is in the Upper Pliocene or Pleistocene deposits [or Quaternary] that are found the remains of the gigantic marsupials—*Diprotodon*, *Macropus titan*, *Nototherium*, and others; and, as their allied representatives now occupy both Australia and New Guinea, it is not improbable that those gigantic animals, whose bones are found in Northern Queensland, also roamed in both those countries. And farther, as the luxuriant vegetation and climatic conditions which we suppose to be favorable for the support of those immense marsupials, still exist in New Guinea, is it rash to conjecture that some of these large creatures may not be living there at the present time? Farther researches may prove this.

10. *Recherches sur les Fossiles Paléozoiques de la Nouvelle Galles du Sud* (Australie); par L.-G. DE KONINCK, D.M. 140 pp. 8vo, with at atlas in 4to. Bruxelles. 1876. (Mem. Soc. Roy. des Sci. de Liege.)—This paper contains descriptions and figures of many Australian species, and of them a considerable number are identical with those of its antipodes, Europe and Britain, or of North America. Among the latter from Silurian beds, are *Halysites escharoides*, *Alveolites repens*, *Favosites cristata*, *F. Forbesi*, *F. aspera*, *F. fibrosa*, *F. Gothlandica*; *Chonetes striatella*, *Leptœna quinquecostata*, *L. compressa*, *Strophomena pecten*, *S. rhomboidalis*, *Pentamerus Knightii*, *P. oblongus*, *Orthis canaliculata*, *Atrypa reticularis*, *A. hemisphærica*, *Spirifer crispus*, *Meristella tumida*; *Pterinea ampliata*, *Orthoceras ibex*, *Cheirurus insignis*, *Encrinurus punctatus*, *Calymene Blumenbachii*, *Bronteus*

Partschii, *Harpes ungula*, and others; and there are as many from the later Paleozoic. The author hence confirms the conclusion expressed by McCoy, with regard to the general specific identity of the marine fauna of the two hemispheres in the Silurian age, and extends it to all Paleozoic time, including the Carboniferous age, so that we may say that "the entire marine Paleozoic fauna was subjected to the same general influences." The species occur in many cases of larger size than in Europe or America. Prof. de Koninck states that he was mainly indebted for the specimens he has described to the Rev. W. B. Clarke, who has long worked in Australian Geology.

11. *On the Syenitic mountains of Ditro, and the Trachytic, Hargitta, near Büdösch in Eastern Transylvania, with observations on the Auriferous Districts of Vöröspatak and Nagyag*, by Prof. G. VOM RATH. 55 pp. 8vo. Bonn, 1876.—The Syenitic mountains of Ditro, described by Prof. vom Rath, extend from Gyergyo Szt. Miklos to Szarhegy and Ditro, having a length of twenty to twenty-one kilometers and a breadth of seven to eight. They consist mainly of "nepheline-syenite" *miascyte*, and "sodalite-syenite" or *ditroyte*. The former, which is the predominating rock, consists of a gray to greenish-gray nephelite (elæolite), white orthoclase and oligoclase, black hornblende with some biotite, zircon, sphene, magnetite, and pyrite, and is either coarse or fine grained. The elæolite is in grains and occasionally in masses two-thirds of an inch through. The miascyte graduates into the ditroyte, or a rock containing blue sodalite and sometimes cancrinite and pyrochlore in addition to the ingredients of the miascyte. The orthoclase of the ditroyte gave Prof. vom Rath the oxygen ratio 1·018 : 3 : 11·438; and the blue sodalite was found by him to consist of

Si 38·66, Al 32·61, Ca 0·95, K 1·04, Na 13·28, Na 3·93, H 2·36, Cl 6·08.

In these mountains there is also a reddish quartzless syenyte-like rock, consisting of a reddish orthoclase, black biotite and hornblende with some yellow sphene.

Prof. vom Rath describes in this paper also the trachytic rocks of the vicinity and their relations, giving analyses of the andesite or plagioclase feldspar; and then discusses the auriferous region and rocks of Vöröspatak and the auriferous tellurium regions of Nagyag (pronounced Nadj-ák). In the Vöröspatak region, as cited from Grimm, the gold-bearing rocks are: (1) the Carpathian sandstone referred to the Eocene containing beds of argillyte, and having vertical ore-bearing veins; (2) a feldstone-porphyry, which is stated to be an eruptive rock, containing quartz in numerous and large dihexahedral crystals; and (3) a "porphyritic sandstone newer than the Carpathian, which is accompanied by a crystalline slate, and sometimes becomes a breccia, and is intersected by numerous small veins of quartz and pyrite.

12. "*Greenstones*" *of Western Cornwall*; J. ARTHUR PHILLIPS, Esq. (Q. J. Geol. Soc., May, 1876.)—This paper has special interest on account of the various opinions with regard to the

relations of diorytes and other "greenstones." The rocks which it describes are greenish slates, greenish crystalline rocks without a trace of lamination, into which the slates pass by gradual or abrupt transitions, and also killas or clay-slate. The kinds of greenstone least metamorphic consist, as seen in thin sections under the microscope, of a plagioclase feldspar, augite or diallage, magnetic titanic iron, with occasional specks of pyrite, and also a little apatite, and with rarely flakes of brown mica, some hornblende, and a chlorite. The more altered kinds have a semi-transparent base, through which hornblende and the chlorite are thickly disseminated; and in it there are green pseudomorphs after augite, and faint outlines of feldspar crystals. In some places there are large crystals of the feldspar, yet with the augite changed to hornblende and chlorite. The material of the intersecting veins is the same, except that it contains a little more green hornblende. In other places the augite is but slightly altered, while the feldspar crystals appear merged in a colorless slightly opaque base, which shows faintly the outlines of the feldspar crystals.

Four different varieties of the greenstones afforded on analysis:

	I.	II.	III.	IV.
Silica	46·32	47·22	43·48	47·26
Alumina	18·18	19·85	18·60	21·64
Ferric oxide	0·82	1·01	3·68	3·97
Ferrous oxide	10·92	9·87	11·38	8·92
Manganous oxide	*trace*	*trace*	*trace*	*trace*
Magnesia	7·46	6·30	6·01	4·02
Lime	9·32	10·18	12·31	6·01
Potash	2·07	1·12	1·12	1·91
Soda	2·95	2·13	1·69	3·77
Phosphoric acid	0·52	0·95	*trace*	0·33
Water, hygrometric	0·24	0·21	0·22	0·29
combined	0·76	0·80	1·17	1·92
Pyrite	0·32	0·17	*trace*	*trace*
	99·88	99·81	99·66	100·04
Specific gravity	3·02	2·97	3·01	2·98

No. 1 is greenish and crystalline, and consists, as shown microscopically, mainly of augite and feldspar, the former predominating, with some chlorite, brown and green hornblende, and magnetite; and came from north of St. Peter's Vicarage in Tolcarn. No. 2, from Tolcarn Quarry, resembles No. 1, but is of lighter color, and consists of feldspar with altered augite, chlorite, magnetite partly replaced by a greenish-gray mineral, and apatite. No. 3, from Tolcarn Quarry, is very fine-grained crystalline, sage-green in color, and consists chiefly of hornblende and altered feldspar and chlorite, the augite being replaced by hornblende and chlorite. No. 4, from Chapel Rock ("which rests on slate"), is crystalline and greenish-gray, somewhat felsytic in appearance and consists of a feldspar base, with crystals of feldspar, hornblende in angular patches replacing augite, chlorite, apatite, magnetite.

With these rocks occur fine-grain crystalline slaty kinds, which

graduate into killas or clay-slate. These slaty crystalline rocks are bluish-green to greenish-gray; and the slaty structure is sometimes wanting. They consist largely of hornblende in minute acicular crystals, with some chlorite, and not unfrequently a slightly opaque base, and with occasional patches of quartz, and sometimes magnetite. An average slaty kind of a dark color gave on analysis the results in column A below. A rock of grayer color, similarly hornblendic, containing much magnetite, afforded the results in column B.

	A	B	C	D
Silica	37·44	50·51	37·63	48·41
Alumina	16·32	19·69	17·15	17·02
Ferric oxide	7·33	1·28	7·53	2·68
Ferrous oxide	14·75	7·40	16·03	9·41
Manganous oxide	*trace*	*trace*	0·40	*trace*
Magnesia	6·06	8·04	3·52	6·20
Lime	12·83	7·38	13·95	13·15
Potash	1·50	1·00	0·94	0·30
Soda	1·85	3·41	0·95	2·13
Water, hygrometric	0·54	0·20	0·40	0·12
combined	0·77	0·63	1·07	0·65
Phosphoric acid	0·27	*trace*	0·46	*trace*
Pyrite	0·23	----	*trace*	*trace*
	88·89	99·67	100·03	100·07
Specific gravity	3·29	2·89	3·35	3·03

(A hornblende of Botallack, Cornwall, having sp. gr.=3·24, afforded A. G. Phillips—Silica 40·12, alumina 16·75, ferric oxide 4·32, ferrous oxide 12·70, manganous oxide 3·42, magnesia 6·82, lime 12·37, potash *trace*, soda 2·65=100·09.)

A compact greenstone, dark greenish black, and crystalline, from Pendower Cove, in Gurnard's Head District, largely made up of hornblende, with an occasional grain of quartz, afforded the composition in column C, above. Another greenstone, bluish gray and distinctly slaty, from two miles west of Camborne, having sp. gr. =3·03, and consisting largely of flakey hornblende as seen under the microscope, afforded the composition of column D. Another, from North Huel Rose, in Newlyn East, was grayish, and had a chert-like aspect, with a tendency to break into plates. The greenstone rocks in St. Ives District consist of hornblendic slates, interbedded with augitic rocks and occasional bands of clay-slate; those of the Cape Cornwall District are stratified, with usually a distinct slaty cleavage.

Mr. Phillips speaks of the greenstones as in part altered gabbro or doleryte; others as metamorphic hornblendic slates, some of them containing garnet, magnetite or axinite; others as killas or ordinary clay slates, containing usually much more silica than the greenstones; others as metamorphic and highly basic hornblendic rocks, having a tendency to break into thin plates.

From the facts connected with the "greenstones" of the western half of the New Haven region and of New Hampshire, it appears probable that even the rocks of dolerytic composition (the augitic

kinds) are ordinary sediments metamorphosed, and constitute either *metadoleryte* or *metadiabase* according to the prevalence of chlorite or not; that part of the hornblendic kinds—those that contain the requisite feldspar—are basic *metadiorytes*, and that the latter pass into hornblendyte (hornblende rock), and also into labradorite-dioryte and anorthite-dioryte, other metamorphic rocks. J. D. D.

13. *Petrographische Studien an den Melaphyrgesteinen Böhmens*, von Dr. E. Boricky. Prag, 1876.—The volume in hand is a continuation of Dr. Boricky's valuable examination of the igneous rocks of Bohemia.

14. *Minerals of New South Wales*, by Prof. A. Liversidge. 63 pp. 8vo. Sydney, N. S. W. 1876.—Prof. Liversidge has given a complete and valuable list of the minerals of New South Wales, with descriptions mostly taken from specimens which he had himself had in hand. The occurrence of gold is described in detail, and an enumeration is given of some of the larger nuggets which have been found. The average chemical composition of the ore obtained is 93½ p. c. gold, and about 6 p. c. silver. E. S. D.

15. *The Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain and Ireland;* No. 1, August. 1876, and No. 2, November, 1876.—The Mineralogical Society of Great Britain and Ireland was instituted February 3d, 1876, with special reference to the advancement of the Sciences of Mineralogy and Petrology. The officers of the Society are as follows: President, H. C. Sorby, Esq.; Vice Presidents, Rev. Professor Haughton and Professor Heddle; Treasurer, R. P. Greg, Esq.; General Secretary, J. H. Collins, Esq.; Foreign Secretary, C. Le Neve Foster, Esq. The first two numbers of the Society's Journal contain a number of interesting papers; among these are descriptions by Mr. J. H. Collins of the following new minerals:

Henwoodite. Occurs in globular masses of a turquois-blue or bluish-green color upon limonite; the exterior surface of the masses shows indistinct crystalline facets. H.=4–4·5, G.=2·67. Analysis: P_2O_5 48·94, AlO_3 18·24, FeO_3 2·74, CuO 7·10, CaO 0·54, SiO_2 1·37, ign. 17·10, loss 3·97=100·00. It is somewhat related to lazulite, wavellite, and turquois, but differs in the relative amounts of alumina and phosphoric acid. Found at the West Phœnix Mine in Cornwall.

Enysite. Occurs in stalactitic forms in a cave at St. Agnes, Cornwall. H.=2–24, G.=1·59. Color bluish-green. B.B. infusible; in the closed tube yields much water. Analysis: SO_3 8·12, AlO_3 29·85, CuO 16·91, CaO 1·35, SiO_2 3·40, H_2O 39·42, CO_2 1·05, Na_2O, Cl, FeO_3 tr.=100·10. The mineral is regarded as one of comparatively recent origin. E. S. D.

16. *Prospectus of the "Zeitschrift für Krystallographie und Mineralogie," under the editorial charge of Prof. P. Groth, "unter Mitwirkung zahlreicher Fachgenossen des In- und Auslandes."*—In this prospectus Dr. Groth gives in full the plan and objects of his new Journal of Crystallography and Mineralogy,

the proposed publication of which has already been announced in this Journal (vol. xii, p. 152). The Zeitschrift will fill a place hitherto unoccupied by any scientific publication being especially devoted to the science of Crystallography in its relation particularly to Mineralogy, and also to the departments of Chemical and Physical Mineralogy. It will thus cover the whole field of mineralogy. Moreover, in addition to original articles, it will contain abstracts of all mineralogical papers wherever they may appear, and in whatever language, and thus become a complete repertorium for the science. To carry out this part of the work, certainly not the least important, the editor has secured the coöperation of leading active mineralogists in England, America, Italy, Denmark, Norway, Russia, Hungary, Bohemia, etc. It is hence evident that the Zeitschrift will be a most invaluable help to all workers in this field of science; and it is much to be hoped that the distinguished and energetic editor will find the hearty support which he deserves, not only in Germany, but in all countries where the science is cultivated. It will be published in octavo numbers of 6 to 7 signatures, commencing with January, 1877. Each volume will include six numbers, and, with the accompanying plates, will cost not more than 30 marks. Authors of original articles will receive free twenty-five extra copies. The publisher is W. Engelmann in Leipzig.

III. Botany and Zoology.

1. *Ulothrix zonata. Ihre geschlechtliche und ungeschlechtliche Fortpflanzung;* Dr. Arnold Dodel.—This paper, which fills the greater portion of the fourth part of the tenth volume of Pringsheim's Jahrbücher, is an important contribution to our knowledge of sexuality in plants in its simplest phase. In spite of the methodical arrangement of the article, it is elaborated with such excessive minuteness, accompanied occasionally by somewhat futile speculation, that it is by no means an easy task to read it. This is to be regretted, as many of the facts brought forward are quite curious. The genus *Ulothrix* belongs to the order *Zoösporeæ* in which the reproduction takes place by means of macrozoöspores and microzoöspores, the former having four cilia and one germinative spot (the name given to the reddish-colored dot found on one side), the latter having only two. The former bodies have for some time been considered non-sexual, while the latter have been supposed to represent sexual organs which by their union form a body with four cilia, and distinguished from the macrozoöspores by having two germinative spots instead of one. This body, which is called the zygospore, corresponds to the organ of the same name in the *Desmideæ* and *Conjugatæ* proper. Dodel confirms the views of Areschoug, Cramer and others, that the macrozoöspores do not conjugate, but, after losing their cilia and coming to rest, grow at once into a new plant. He also agrees, in the main, with Areschoug as to the conjugation of the microzoöspores, and besides has been able to give a more exact account

of what becomes of the zygospores. He finds that they remain for a considerable time unchanged, and finally divide into a number of zoöspores, which soon come to rest and grow into new plants, as in the case of the macrozoöspores. The latter it appears are more common in winter and spring, and were produced abundantly on thawing tufts which had been frozen, while the microzoöspores are more common in summer.

The most curious fact observed by Dodel is that those microzoöspores which, for any reason, do not succeed in conjugating, grow at once into new plants just as in the case of the macrozoöspores. In other words, the sexual process is reduced to the direct union of two bodies so similar that it is impossible to distinguish one as male and the other as female, and furthermore these bodies, if not placed in conditions favorable for conjugating, can at once grow into new plants. It would be difficult to find sexuality of a lower grade than this, where each sexual organ is also capable of reproducing the plant by non-sexual growth. We would recall the case of *Eurotium herbariorum* mentioned by De Bary, where, of the several male organs (pollinodia) only one succeeds in coming in contact with the female organ, yet all, after the fertilization has taken place, continue to grow and take part in the formation of the sac which eventually encloses the spores. With very rare exceptions in the Thallogens, the male organ at once atrophies after fertiiization has been accomplished.

W. G. F.

2. *De Copulatione Microzoosporarum Enteromorphæ compressæ*, (L.) Scripsit J. E. Areschoug, ex Botaniska Notiser. 1876. No. 5.—In their Observations sur quelques algues possédant des zoospores dimorphes, Janczewski and Rostafinski called in question the observations of Areschoug in which he maintained that the microzoöspores of *Enteromorpha compressa* conjugated. In the present paper Areschoug gives a detailed account of repeated observations of the conjugation of microzoöspores of *Enteromorpha compressa* made during the past summer, and it would appear that Janczewski and Rostafinski had been too hasty in their criticisms. Areschoug mentions that Wittrock has found zygospores in *Hæmatococcus lacustris* (*Protococcus nivalis*) the existence of which Rostafinski denied. W. G. F.

3. *Professor Sir Wyville Thomson on some of the Echinoderms of the "Porcupine" and "Challenger" Expeditions.*—One of the recent numbers of the Transactions of the Royal Society of London contains an account by Professor Thomson of the Echini of the "Porcupine." The most interesting portion is a full description with excellent figures of several species of the new family of Echini with flexible test, intermediate between the Cidaridæ and Diadematidæ, the genera *Thermosoma*, *Calveria* and *Asthenosoma* constituting the family. The structure of the Echinothuriæ, as this family has been called by Sir Wyville, throws a good deal of light on the affinities of the extinct Palæechinidæ.

In addition to the Crinoids noticed by Professor Thomson in one of his former preliminary reports addressed to the Royal Society, he has published a short account of two remarkable genera belonging to the family of Apiocrinidæ, which are described as *Bathycrinus* and *Hyocrinus*, the former from a depth of 2475 fathoms, south of Cape Clear, the latter from a depth of 1850 fathoms, 300 miles east of St. Paul's Rocks. The paper is illustrated by five cuts, and forms the beginning of No. 66 of the Journal of the Linnean Society for December, 1876. *Bathycrinus* is allied to *Rhizocrinus*, while *Hyocrinus* has a superficial resemblance to *Poteriocrinus* and *Cyathocrinus*. In the same number of the Journal of the Linnean Society, Sir Wyville Thomson has given a most interesting account of the direct mode of propagation in a number of Echinoderms, showing that this mode of reproduction is not so exceptional among Echinoderms as was formerly supposed. The direct mode of reproduction was already known in all the orders of Echinoderms (Holothurians, Ophiurans, Starfishes, Echini and Crinoids). It had however been supposed that the plutean development was the normal mode of reproduction among Echinoderms, although the complete homology between the direct and plutean embryology has been pointed out by several writers on the Echinoderms. The sketch referred to shows most conclusively that this view was correct and opens a most interesting field of speculation regarding the causes which may have brought about, often in closely allied genera, one or the other mode of reproduction. It is somewhat curious that the majority of cases of direct reproduction are of species found in the northern regions of the old world, the species observed by Professor Thomson are all from the Southern Sea; Falkland Islands (*Cladodactyla crocea* Lessen, *Goniocidaris canaliculata* A. Ag.); Heard Island (*Prolus ephipper*); Kerguelen Isls. (*Cidaris nutrix* W. T., *Hemiaster*, sp. *Archaster excavatus* W. T., *Hymenaster*, and *Ophiocoma didelphys* W. T. These species are all figured with the young as they are carried about by the parent. A. AG.

4. *Zoology of the Challenger Expedition.*—The editors learn by letter from Mr. ALEXANDER AGASSIZ (dated Edinburgh, Dec. 18) that he has found the material a wonderful collection, and was deeply impressed by the great amount of it, coming as it mainly does from the depths with which we formerly associated the idea of a lifeless desert region. He also gives the following information respecting the publication of the results. "The Admiralty is to publish the results and the collections are to be worked up by sundry specialists: Allman the Hydrozoa; Busk the Polyzoa; Dr. McIntosh the Annelids; Thomson himself the Crinoids and some of the Sponges, the balance of the latter by O. Schmidt; Hæckel the Radiolaria; Moseley of the Challanger the Polyps; Murray who was on the Challenger will work up the deep sea bottoms and surface animals (Foraminifera, etc.); Günther the Fishes. Some of the groups are not yet determined upon, but the same persons who worked up the "Porcupine" species will probably have charge

of the Challenger collection. Young Carpenter will work up the Comatulæ, Lyman will have the Ophiurans, and I shall bring over with me the Echini and perhaps some other group of Echinoderms, so that the United States will have their fair share of the work."

5. *Rate of Growth of Corals.*—A remarkable piece of coral, taken off the submarine cable near Port Darwin, is spoken of by the Cocktown Herald. It is of the ordinary species, about five inches in height, six inches in diameter at the top, and about two inches at the base. It is perfectly formed, and the base bears the distinct impression of the cable, and a few fibers of the coir rope used as a sheath for the telegraphic wire still adhering to it. As the cable has been laid only four years it is evident that this specimen must have grown to its present height in that time, which seems to prove that the growth of coral is much more rapid than has been supposed.—*Melbourne paper.*

7. *Bulletin of the Nuttall Ornithological Club.* Editor, J. A. Allen; Associate Editors, S. F. Baird and Elliott Coues.—The November number closed the first volume of this excellent journal. It contains papers by E. Ingersoll, Dr. J. G. Cooper, R. Ridgeway, J. C. Merrill, M.D., U.S.A., and T. M. Brewer, besides notices of recent publications and various miscellaneous notices.

The Journal has the best of American Ornithologists among its contributors, and is afforded at the low rate of one dollar a year (postage included). All interested in Birds, or in the progress of science, will find the small sum asked for subscription a good outlay. The prospectus states that, for the sake of sustaining the Journal, an advertising sheet will be inserted, and low rates of advertisement charged. Subscriptions should be forwarded to Mr. H. B. Bailey, Newton, Mass., and communications or advertisements to Mr. J. A. Allen, Museum of Comparative Zoology, Cambridge, Mass.

IV. Astronomy.

1. *Meteor of Dec. 21st*, 1876.—On the evening of Thursday, Dec. 21st, 1876, a meteor of unusual size and brilliancy passed over the States of Kansas, Missouri, Illinois, Indiana, and Ohio. In many respects it is worthy of special record. From newspaper notices that we have been able to collect, from a few private letters, and from some letters kindly sent us by Prof. Henry, from the Smithsonian Institution, we are able to give a general account of the body.

It was first seen, so far as we know, over the State of Kansas, and probably as far west as the center of the State. It passed nearly over and probably south of the cities of Topeka and Leavenworth, being there at an altitude of about 60 miles. It crossed the Mississippi between Hannibal and Keokuk, but nearer to the former place. Over the center of the State of Missouri one or more explosions occurred, and shortly after crossing the Mississippi it broke into several fragments. The breaking up continued while it was crossing the States of Illinois, Indiana and Ohio. A

loud explosion is reported as far east as Concord and Erie, Pa. The meteor consisted in fact of a large flock of brilliant balls chasing each other across the sky, the number being variously estimated from a score to a hundred. This flight is of peculiar interest in view of the long continued violent disintegration.

The region around Chicago was overcast, and though the clouds were lighted up in a most remarkable manner no sound seems to have been heard. In like manner no sound is reported from St. Louis. But over all the region of Central Illinois between these two cities a terrific series of explosions were heard. In Keokuk, Ia., it was heard, but not elsewhere in that State so far as appears from these accounts. A rumbling is reported as far south of the track as Bloomington, Ind., 120 miles distant, but whether it was caused by the meteor is doubtful. Yet over the northern part of Indiana the passage of the body was followed by loud explosions.

Whether a portion of the body pursued its way onward over New York State and out of the atmosphere is from the statements before us doubtful. The path was nearly parallel to the earth's surface and might easily be in its latter part upward. But if the sky was then clear over western New York the meteor would in such case certainly have been seen in that region.

The path was about N. 75° E., and was nearly or quite a straight line and not less than 1,000 miles long. The duration of flight was of course variously estimated, from fifteen seconds up to three minutes, and yet no one probably saw the body through more than a fraction of its path.

It entered the air in a course differing only about 30° from the earth's motion and was overtaking the earth. Its real motion made therefore a still smaller angle with that of the earth. But the relative velocity was so slow, probably not over ten or fifteen miles a second, that the earth's attraction had changed its direction greatly. It must have been coming, previous to that change, from a point near to and a little south of the ecliptic in the eastern or southern part of the constellation Capricornus. There appears to be no known meteor-radiant at that time near that part of the heavens.

Should no one else undertake the complete discussion of this meteor, we may treat it more fully in a future number of the Journal. We shall be grateful for any accounts of observers—especially of those who made angular measurements—whether we shall use them ourselves or place them in the hands of others for reduction. H. A. N.

V. Miscellaneous Scientific Intelligence.

1. *Bressa Prize, of the Turin Academy of Sciences.*—The fund for the Bressa prize—instituted by the bequest of M. César Alexandre Bressa, Doctor of Medicine and Surgery, who died in 1835—became available in 1876. A prospectus issued by the Royal Academy announces that, in carrying out the will of the testator, a prize, amounting to the income of two years, will be given in 1879, and every four years thereafter, to the man of science, *of*

whatever country, who shall, in the judgment of the Academy, have made, during the preceding four years, the most brilliant and useful discovery, or shall have published the most celebrated work, in pure or applied mathematics, or in the physical sciences, such as physics, chemistry, physiology, natural history, or in geology. pathology, history, geography or statistics; and, secondly, the same amount, on the same conditions, in 1881, and every four years thereafter, to an Italian savant. The prize will not be given to any of the National members of the Academy, resident or non-resident. The amount of the prize given in 1879 will be 12,000 francs.

2. *Annual Report of the Board of Regents of the Smithsonian Institution for* 1875.—The work of the Smithsonian Institution covers a wide range of subjects of both economical and scientific importance, and has a powerful influence for good on the welfare and scientific progress of the nation. As one example we cite the fact, stated in this report, that the department of the Institution having charge of fish-culture, which is under the direction of Professor Baird, distributed in the years 1874, 1875, of young shad, 18,689,550; of Penobscot salmon, 2,294,565; of California salmon, 4,581,340; making in all over twenty-five and a half millions which, with the distribution during the winter and spring of 1875-6, of these and other fishes, make a total of forty million fish supplied by the Commission in three years. The Report on the Museum shows great increase. One object of special interest acquired during the year, is the Tucson meteorite, presented by Dr. B. J. D. Irwin, U. S. A. The very extensive collections displayed by the Smithsonian Institution at the International Exposition at Philadelphia were second in interest to none there exhibited. Very much of the credit connected with it is due to Dr. S. F. Baird, the assistant secretary of the Institution, who gives in this volume a statement of the general scheme of arrangements.

The general appendix to the Report contains the following papers,—Eulogy of Volta, by Arago; The probable future of the Human race, by A. de Candolle; Report on the Transactions of the Society of Physics and Natural History of Geneva, 1873 to July, 1874; The "Past and Future of Geology," by Joseph Prestwich; Report of the Special Committee for the Consideration of the Memoir of H. G. Wex on the diminution of the water of rivers; The refraction of Sound, by Wm. B. Taylor; On the organization of local Scientific Societies, by Professor Henry; On Ethnology: International Code of Symbols for Charts of Pre-historic Archæology, translated by O. T. Mason; Characteristics of Ancient Man in Michigan, by H. Gilman; The Stone Age in New Jersey, by Dr. C. C. Abbott. The Ethnological papers are illustrated by a large number of figures of stone implements, skulls, etc.

3. *The Theory of Sound in its relation to Music;* by Professor Pietro Blaserna, of the Royal University of Rome. 188 pp. 12mo, with numerous woodcuts. New York, 1876. (D. Appleton & Co.)—This is a popular work in style by one who is deeply versed in the science of the subject of which it treats, and knows how to present its principles and facts briefly and clearly.